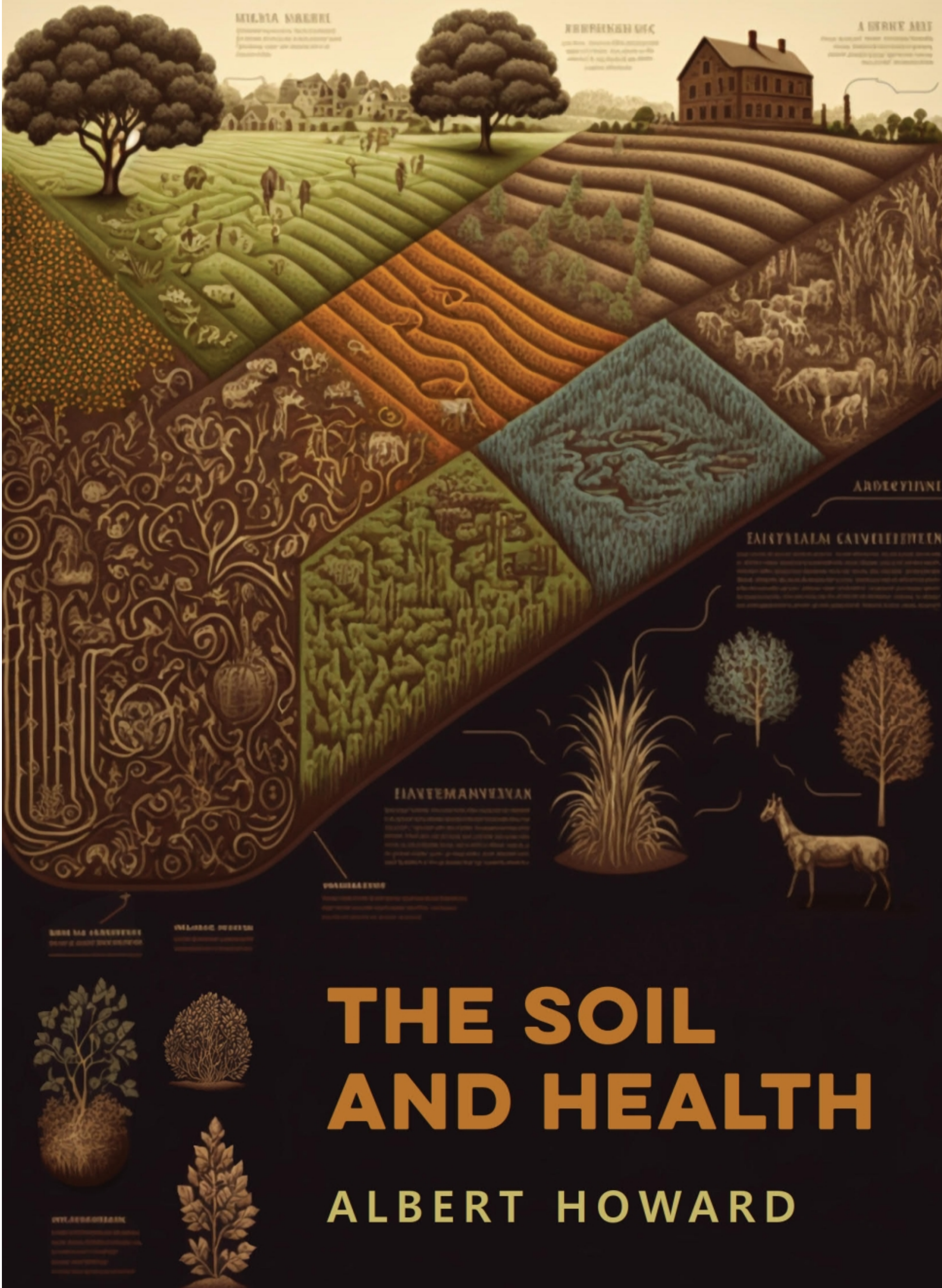
FARMING AND GARDENING FOR INDIVIDUAL AND COMMUNAL HEALTH



THE SOIL AND HEALTH

ALBERT HOWARD

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INDIVIDUAL AND COMMUNAL HEALTH

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THE SOIL AND HEALTH

by Albert Howard

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Preface

The Earth's green carpet is the sole source of the food consumed by livestock and mankind. It also furnishes many of the raw materials needed by our factories. The consequence of abusing one of our greatest possessions is disease. This is the punishment meted out by Mother Earth for adopting methods of agriculture which are not in accordance with Nature's law of return. We can begin to reverse this adverse verdict and transform disease into health through the proper use of the green carpet — by the faithful return to the soil of all available vegetable, animal, and human wastes.

The purpose of this book is threefold:

1. to emphasise the importance of solar energy and the vegetable kingdom in human affairs;
2. to record my own observations and reflections, which have accumulated during some 45 years, on the occurrence and prevention of disease; and
3. to establish the thesis that most of this disease can be traced to an impoverished soil, which then leads to imperfectly synthesised protein in the green leaf and finally to the breakdown of those protective arrangements which Nature has designed for us.

During the course of the campaign for the reform of agriculture, now in active progress all over the world, I have not hesitated to question the soundness of present-day agricultural teaching and research — due to failure to realise that the problems of the farm and garden are biological rather than chemical.

It follows, therefore, that the foundations on which the artificial fertiliser and poison spray industries are based are also unsound. As a result of this onslaught, what has been described as the war in the soil has broken out in many countries and continues to spread. The first of the great battles now being fought began in South Africa some ten years ago and has ended in a clear-cut victory for organic farming. In New Zealand the struggle closely follows the course of the South African conflict. The contest in Great Britain and the United States of America has only now emerged from the initial phase of reconnaissance, in the course of which the manifold weaknesses of the fortress to be stormed have been discovered and laid bare.

I am indebted to some hundreds of correspondents all over the world for sending me reports of the observations, experiments, and results which have followed the faithful adoption of Nature's great law of return. Some of this information is embodied and acknowledged in the pages of this book. A great deal still remains to be summarised and reduced to order — a labour which I hope soon to begin. When it is completed, a vast mass of material will be available which will confirm and extend what is to be found in these pages.

Meanwhile a portion of this evidence is being recorded by Dr Lionel J. Picton, in the *News-Letter on Compost* issued three times a year by the County Palatine of Chester Local Medical and Panel Committees at Holmes Chapel, Cheshire. By this means the story begun in their *Medical Testament* of 1939 is being continued and the pioneers of organic farming and gardening are kept in touch with events.

The chapter on *The Maintenance of Soil Fertility in Great Britain* (p.74) is very largely based on the labours of a friend and former colleague, the late Mr George Clarke, who, a few days before his untimely death in May 1944, sent me the results of his study of the various authorities on the Saxon Conquest, the evolution of the manor, the changes it underwent as the result of the Domesday Book, and the enthronement of the feudal system until the decay of the open-field system and its replacement by enclosure.

The spectacular progress in organic farming and gardening which has taken place in South Africa and Rhodesia during the last few years owes much to the work of Captain Moubray, Mr J. van Vuren, and Mr G. Dymond, who have very generously placed their results at my disposal. Captain Moubray and Mr van Vuren have contributed two valuable appendices, while Mr Dymond's pioneering work on virus disease in the cane and on composting at the Springfield Sugar Estate in Natal has been embodied in the text. For the details relating to the breakdown of the cacao industry in Trinidad and on the Gold Coast and for a number of other suggestions on African and West Indian agriculture, I am indebted to Dr H. Martin Leake, formerly Principal of the Imperial College of Tropical Agriculture, Trinidad.

I have been kept in constant touch with the progress of organic farming and gardening in the United States of America by Mr J. Rodale of Emmaus, Pa., the editor of *Organic Gardening*, who has started a movement in the New World which promises soon to become an avalanche. Mr Rodale was the prime mover in bringing out the first American edition of *An Agricultural Testament* and is responsible for the simultaneous publication of this present book in the United States and of a special American edition of Eve Balfour's stimulating work *The Living Soil*.

In India I have made full use of the experience of Colonel Sir Edward Hearle Cole, on the Coleyana Estate in the Punjab, and of Mr E. Watson's work on the composting of water hyacinth at Barrackpore. Walter Duncan & Company have generously permitted Mr J. Watson to contribute an appendix on the remarkable results he has obtained on the Gandrapara Tea Estate in North Bengal. In this fine property India and the rest of the Empire possess a perfect example of the way Nature's law of return should be obeyed and of what freshly prepared humus by itself can achieve.

I owe much to a number of the active members of the New Zealand Compost Club, and in particular to its former

Secretary, Mr T. Ashby, who have kept me fully informed of the results obtained by this vigorous association. The nutritional results obtained by Dr G. Chapman, the President, at the Mount Albert Grammar School, which show how profoundly the fresh produce of fertile soil influences the health of schoolboys, have been of the greatest use.

In Eire the Rev. Sowby, Warden of the College of St. Columba, Dublin, and the Rev. Airy, Head Master of St. Martin's School, Sidmouth, have placed at my disposal the results of similar work at their respective schools. These pioneering efforts are certain to be copied and to be developed far and wide. Similar ideas are now being applied to factory canteen meals in Great Britain with great success, as will be evident from what Mr George Wood has already accomplished at the Co-operative Wholesale Society's bacon factory at Winsford in Cheshire.

For furnishing full details of a large-scale example of successful mechanised organic farming in this country and of the great possibilities of our almost unused downlands, I owe much to Mr F. Sykes. The story of Chantry, where the results of humus without any help from artificial fertilisers are written on the land itself, provides a fitting conclusion to this volume.

In the heavy task of getting this book into its final shape I owe much to the care and devotion of my private secretary, Miss Ellinor Kirkham.

Albert Howard
London

"The staple foods do not contain the same nutritive substances as in former times.

Chemical fertilisers, by increasing the abundance of the crops without replacing all the exhausted elements of the soil, have contributed to changes in the nutritive value of grains and vegetables.

Hygienists have not paid sufficient attention to the genesis of diseases. Their studies of conditions of life and diet, and of their effects on the physiological and mental state of modern man, are superficial, incomplete, and of too short duration.

They have, thus, contributed to the weakening of our body and our soul."

— Alexis Carrel, *Man the Unknown*

CONTENTS

“The civilised nations have been sustained by the primitive forests which anciently rotted where they stood. They survive as long as the soil is not exhausted.”

— Thoreau, *Walking and the Wild*.

“The preservation of fertility is the first duty of all who live by the land.

There is only one rule of good husbandry — leave the land better than you found it.”

— George Henderson, *The Farming Ladder*

INTRODUCTION

An adventure in research

My first post was a somewhat unusual one. It included the conventional investigation of plant diseases, but it combined these duties with work on general agriculture; officially I was described as ‘Mycologist and Agricultural Lecturer to the Imperial Department of Agriculture for the West Indies’.

The headquarters of the department were at Barbados. While I was provided with a laboratory for investigating the fungal diseases of crops (mycology) and was given special facilities for the study of the sugar cane, in the Windward and Leeward Islands my main work was much more general — the delivery of lectures on agricultural science to groups of schoolmasters to help them to take up nature study and to make the fullest use of school gardens.

Looking back, I can now see where the emphasis of my job rightly lay. In Barbados I was a laboratory hermit, a specialist of specialists, intent on learning more and more about less and less: but during my tours of the various islands I was forced to forget my specialist studies, and become interested in the growing of crops, which in these districts were principally cacao, arrowroot, ground nuts, sugar cane, bananas, limes, oranges, and nutmegs. This contact with the land itself and with the practical people working on it laid the foundations of my knowledge of tropical agriculture.

This dual experience had not long been my life before I became aware of one disconcerting circumstance. I began to detect a fundamental weakness in the organisation of that research which constituted officially the more important part of my work. I was an investigator of plant diseases, but I had myself no crops on which I could try out the remedies I advocated: I could not take my own advice before offering it to other people.

I realised that there was a wide chasm between science in the laboratory and practice in the field, and I began to suspect that unless this gap could be bridged, no real progress could be made in the control of plant diseases. Research and practice would remain apart: mycological work threatened to degenerate into little more than a convenient agency by which — provided I issued a sufficient supply of learned reports fortified by a judicious mixture of scientific jargon — practical difficulties could be endlessly side-tracked.

Towards the end of 1902, therefore, I took steps which terminated my appointment and gave me a fresh start. My next post was more promising — that of Botanist to the South-Eastern Agricultural College at Wye in Kent, where in addition to teaching, I was placed in charge of experiments on the growing and drying of hops which had been started by the former principal, Sir Daniel Hall.

These experiments brought me into contact with a number of the leading hop growers, notably Sir Walter Berry, Mr Alfred Amos, and Colonel Honyball — all of whom spared no pains in helping me to understand the cultivation of this most interesting crop. I began to raise new varieties of hops by hybridisation and at once made a significant practical discovery — the almost magical effect of pollination in speeding up the growth and also in increasing the resistance of the developing female flowers (the hops of commerce) to green-fly and mildew (a fungal disease) which often did considerable damage.

The significant thing about this work was that I was meeting the practical workers and growers on their own ground. Actually their practice — that of eliminating the male plant altogether from their hop gardens — was a wide departure from natural law. My suggestion amounted to a demand that Nature be no longer defied. It was for this reason highly successful. By restoring pollination, the health, the rate of growth, and finally the yield of hops were improved. Soon the growers all over the hop-growing areas of England saw to it that their gardens were provided with male hops, which liberated ample pollen just as it was needed.

This, my first piece of really successful work, was done during the summer of 1904 — five years after I began research. It was obtained by happy chance and gave me a glimpse of the way Nature regulates her kingdom: it also did much to strengthen my conviction that the most promising method of dealing with plant diseases lay in prevention — by correcting and refining agricultural practice.

But to continue such work the investigator would need land and hops of his own, with complete freedom to grow them in his own way. Such facilities were not available and did not seem possible at Wye.

Then my chance came. Early in 1905, I was offered and accepted the post of Economic Botanist at the Agricultural Research Institute about to be founded by Lord Curzon, then Viceroy of India, at Pusa in Bengal.

On arrival in India in May 1905 the new institute only existed on paper, but an area of about 75 acres of land at one end of the Pusa Estate was available. I secured it instantly and spent my first five years in India learning how to grow the crops which it was my duty to improve by modern plant-breeding methods.

It was a decided advantage that officially my work was now no longer concerned merely with the narrow problem of disease. My main duties at Pusa were the improvement of crops and the production of new varieties. Over a period of nineteen years (1905–24) my time was devoted to this task, in the course of which many new types of wheat (including rust-resistant varieties), as well as tobacco, gram, and linseed were isolated, tested, and widely distributed.

In pursuance of the principle I had adopted of joining practice to my theory, the first step was to grow the crops I had to improve. I determined to do so in close conformity with local methods. Indian agriculture can point to a history of many centuries: there are records of the same rice fields being farmed in north-east India which go back for hundreds of years. What could be more sensible than to watch and learn from an experience which had passed so prolonged a test of time? I therefore set myself to make a preliminary study of Indian agriculture, and speedily found my reward.

Now the crops grown by the cultivators in the neighbourhood of Pusa were remarkably free from pests: such things as insecticides and fungicides found no place in this ancient system of cultivation. This was a striking fact, and I decided to break new ground and try out an idea which had first occurred to me in the West Indies and had forced itself on my attention at Wye — namely, to observe what happened when insect and fungal diseases were left alone and allowed to develop unchecked, with indirect methods only — such as improved cultivation and more efficient varieties — being employed to prevent attacks.

In pursuit of this idea, I found I could do no better than watch the operations of the peasants, and regard them and the pests, for the time being, as my best instructors.

In order to give my crops every chance of being attacked by parasites, nothing was done in the way of direct prevention; no insecticides and fungicides were used; no diseased material was ever destroyed. As my understanding of Indian agriculture progressed and as my practice improved, a marked diminution of disease in my crops occurred. At the end of five years' tuition under my new professors — the peasants and the pests — the attacks of insects and fungi on all crops whose root systems suited the local soil conditions became negligible.

By 1910 I had learnt how to grow healthy crops, practically free from disease, without the slightest help from mycologists, entomologists, bacteriologists, agricultural chemists, statisticians, clearing-houses of information, artificial fertilisers, spraying machines, insecticides, fungicides, germicides, and all the other expensive paraphernalia of a modern experimental station.

This preliminary exploration of the ground suggested that the birthright of every crop is health.

In the course of the cultivation of the 75 acres at my disposal, I had to make use of the ordinary power unit in Indian agriculture; the ox. It then occurred to me that the same practices which had been so successful in the growing of my crops might be worthwhile if applied to my animals. To carry out such an idea it was necessary to have these work cattle under my own charge, to design their accommodation, and to arrange for their feeding, hygiene, and management.

At first this was refused, but after persistent importunity backed by the support of the member of the Viceroy's Council in charge of agriculture (Sir Robert Carlyle), I was allowed to have charge of six pairs of oxen. I had little to learn in this matter, as I belong to an old agricultural family and was brought up on a farm which had made for itself a local reputation in the management of cattle. My work animals were most carefully selected and everything was done to provide them with suitable housing and with fresh green fodder, silage, and grain, all produced from fertile land.

I was naturally intensely interested in watching the reaction of these well-chosen and well-fed oxen to diseases like rinderpest, septicaemia, and foot-and-mouth disease which frequently devastated the countryside. (These epidemics are the result of starvation, due to the intense pressure of the bovine population on the limited food supply.)

None of my animals were segregated; none were inoculated; they frequently came into contact with diseased stock. As my small farmyard at Pusa was only separated by a low hedge from one of the large cattle-sheds on the Pusa estate, in which outbreaks of foot-and-mouth disease often occurred, I have often seen my oxen rubbing noses with foot-and-mouth cases.

Nothing happened. The healthy, well-fed animals failed to react to this disease just as suitable varieties of crops, when properly grown, failed to succumb to insect and fungal pests — no infection took place. These experiences were afterwards repeated at Indore in Central India, but here I had 40, not twelve, oxen. A more detailed account of the prevention and cure of foot-and-mouth disease is given in Chapter 9.

These observations, important as they appeared both at the time and in retrospect, were however only incidental to my main work which was, as already stated, the improvement of the varieties of Indian crops, especially wheat. It was in the testing of the new kinds, which in the case of wheat soon began to spread over some millions of acres of India, that there gradually emerged the principle of which my observations about disease provided the first links in evidence: namely, that the foundations of all good cultivation lie not so much in the plant as in the soil: and there is so intimate a connection between the state of the soil, i.e. its fertility, and the growth and health of the plant as to outweigh every other factor.

Thus on the capital point of increase of yield: if by improvement in selection and breeding my new special varieties of wheat, etc., might be estimated to produce an increase of 10–15 per cent, such yields could at once be increased not merely by this paltry margin, but doubled or even trebled, when the new variety was grown in soil brought up to the highest state of fertility.

My results were afterwards amply confirmed by my colleague, Mr George Clarke, who, by building up the humus content of his experimental station at Shahjahanpur in the United Provinces and by adopting simple improvements in cultivation and green manuring, was able to treble the yields of sugar cane and wheat.

Between the years 1911 and 1918, my experience was considerably enhanced by the study of the problems underlying irrigation and fruit growing. For this purpose I was provided with a small experimental farm on the loess soils of the Quetta valley in Baluchistan where, until 1918, the summer months were spent. After a supply of moisture had been provided to supplement the scanty winter rainfall, the limiting factors in crop production proved to be soil aeration and the humus content of the land.

Failure to maintain aeration was indicated by a disease of the soil itself. The soil flora became anaerobic, alkali salts developed, and the land died. The tribesmen kept the alkaline condition at bay in their fruit orchards in a telling manner — by means of the deep-rooting cover crop lucerne, combined with surface dressings of farmyard manure. Moreover, they invariably combined their fruit growing with mixed farming and livestock. Nowhere, as in the West, did one find the whole farm devoted to fruit with no provision for an adequate supply of animal manure.

This method of fruit growing was accompanied by an absence of insect and fungal diseases. Spraying machines and poison sprays were unheard of, and artificial fertilisers were never used.

The local methods of grape growing were also intensely interesting. To save the precious irrigation water and as a protection from the hot, dry winds, the vines were planted in narrow ditches dug on the slopes of the valley and were always manured with farmyard manure. Irrigation water was led along the ditches, and the vines were supported by the steep sides of the trenches. At first sight, all the conditions for insect and fungal diseases seemed to be provided, but the plants were remarkably healthy. I never found even a trace of disease. The quality of the produce was excellent: the varieties grown were those which had been in cultivation in Afghanistan for centuries. No signs of 'running out' were observed. Here were results in disease resistance and in the stability of the variety in striking contrast to those of western Europe, where disease is notorious, the use of artificial fertilisers and poison sprays is universal, and where the running out of the variety is constantly taking place (see also *Chapter 8, Vine*).

These results and observations, taken together and prolonged over a period of nineteen years, at length indicated the correct method of approach to the work I was doing.

Improvement of varieties, increased yields, and freedom from disease were not distinct problems, but formed parts of one subject and, so to speak, were members one of another, all arising out of the great linkage between the *soil*, the *plant*, and the *animal*.

The line of advance lay not in dealing with these factors separately, but together. If this were to be the path of progress and if it was useless to proceed except on the basis of crops grown on fertile land, then the first prerequisite for all subsequent work would be the bringing of the experimental station area to the highest state of fertility, and maintaining it in that condition.

This, however, opened up a further problem. The only manure at the command of the Indian cultivator was farmyard manure; so it was therefore essential — but even on the experimental stations, the supply of this material was always insufficient. The problem was how to increase it in a country where a good deal of the cattle dung is burnt for fuel. No lasting good could be achieved unless this problem was overcome, for no results could be applied to the country at large.

The solution was suggested by the age-old practices of

China, where a system of utilising farm wastes and turning them into humus had been evolved which, if applied to India, would make every Indian farm self-supporting with regard to manure. This idea called for investigation.

I now came up against a great difficulty. Such a problem did not fall within my official sphere of work. It obviously necessitated a great deal of chemical and agricultural investigation under my personal control, and complete freedom to study *all* aspects of the question. But while my idea was taking shape, the organisation of agricultural research at Pusa had also developed.

A series of separate compartments — plant breeding, mycology, entomology, bacteriology, agricultural chemistry, and practical agriculture — had become firmly established. Vested interests were created which regarded the organisation as more important than its purpose. There was no room in it for a comprehensive study of soil fertility and its many implications by one member of the staff with complete freedom of action. My proposals involved 'overlapping', a defect which was anathema both to the official mind (which controlled finance) and to a research institute as subdivided into fiefdoms as Pusa always had been.

The obvious course was to leave the institute and to collect the funds to found a new centre, where I could perform my researches unhampered and undisturbed. After a delay of six precious years, 1918-24, the Indore Institute of Plant Industry (at which cotton was the principal crop) was founded, where I was provided with land, ample money, and complete freedom. Now the fundamental factor underlying the problems of Indian cotton was none other than the raising of soil fertility. I might, therefore, kill two birds with one stone; I could solve the cotton problem, and also increase the amount of farmyard manure for India as a whole.

At Indore, I had a considerably larger area at my disposal, namely 300 acres. From the outset, the principles which I had worked out at Pusa were applied to cotton. The results were even better. The yield of cotton was almost trebled and the whole experimental station stood out from the surrounding countryside by reason of the fine crops grown there.

Moreover, these crops were free from disease, with only two exceptions, during the whole eight years of my work there — exceptions which in themselves were highly significant.

1. A small field of gram, which had become accidentally waterlogged three months before the crop was sown, was, a month after sowing, found to be heavily attacked by the gram caterpillar, the infected areas corresponding exactly with the waterlogged areas, while the rest of the plot remained unaffected: the caterpillar did not spread, though nothing was done to check it.
2. A field of sunn hemp (*Crotalaria juncea*)[1], originally intended for green manuring, was allowed to flower for seed; after flowering it was smothered in mildew and insect pests, and no seed set. Subsequent trials showed that this crop will set seed and be disease-free on black soils only if the land is previously well manured with farmyard manure or compost.

These results were progressive confirmation of the principle I was working out — the connection between land in good health and disease-free crops: they were proof that as soon as land drops below par, disease sets in. The first case showed the supreme importance of keeping the physical texture of the soil right, the second was an interesting

1. *Crotalaria juncea* is known as brown hemp, Indian hemp, Madras hemp, or sunn hemp. It is a tropical Asian plant of the legume family (Fabaceae), generally considered to have originated in India. It is now widely grown throughout the tropics and subtropics as a source of green manure, fodder and lignified fiber obtained from its stem. Sunn hemp is also being looked at as a possible bio-fuel. It can be an invasive weed and has been listed as a noxious weed in some areas.

example of the refusal of Mother Earth to be overworked, of her unbreakable rule to limit herself strictly to that volume of operations for which she has sufficient reserves: flowers were formed, but seed refused to set and the mildew and insects were called in to remove the imperfect product.

These were the exceptions that proved the rule, for during the eight years of my work at Indore, it was assumed by me as a preliminary condition to all experiments that my fields must be fertile. This was brought about by supplying them with heavy dressings of compost made on a simple development of the Chinese system. As I was now free, it was possible for me to make these arrangements on a large scale, and in the course of doing so, it seemed well worthwhile to work out the theory that underlies the Chinese practice.

A series of experiments and investigations were carried out, establishing the main chemical, physical, and biological processes responsible for humus formation in the making of compost. In this work I received valuable help from Mr Y. Wad who was in charge of the chemical side of the investigation.

On my retirement from official service in 1931, I assumed that the publication of this joint work in book form would be the last scientific task which I should ever undertake.

It proved instead to be the beginning of a new period which has been based on the long preparation which preceded it: the years of work and experiment carried out in the tropics had gradually, but inevitably, led me up to the threshold of ideas which embrace and explain the facts and the practices, the theory and also the failures, which had met me in the course of these 32 years.

Our book on *The Waste Products of Agriculture; Their Utilisation as Humus*, designed to be a practical guide to assist the Indian cotton cultivators, evoked a much wider interest. The so-called 'Indore Process' of making compost was started at a number of centres in other countries, and interesting results began to be reported, very similar to what I had obtained at Indore.

Two years after publication, in February 1933, I saw the inception of a compost-making scheme at Colonel Grogan's estate not far from Nairobi in Kenya. During this visit, it first occurred to me to terminate all my other activities, and to confine myself to encouraging the pioneers engaged in agriculture all over the world to *restore and maintain the fertility of their land*.

This would involve a campaign to be carried out single-handed at my own expense, as no official funds could be expected for a project such as mine. Even if I could have obtained the means needed, it would have been necessary to work with research organisations I had long regarded not only as obsolete, *but as the perfect means of preventing progress*.

A soil fertility campaign carried on by a retired official would also throw light on another question — the relative value of complete freedom and independence in getting things done in farming, as compared with the present cumbrous and expensive governmental organisations.

By the end of 1933, matters had progressed far enough to allow the introduction of the Indore Process to a wider public. This was done by means of two lectures before the Royal Society of Arts in 1933 and 1935, some thousands of extra copies of both of which were distributed all over the world, along with subsequent contributions to the journal of that society, to the German periodical *Der Tropenpflanzer*, and also to a Spanish review, the *Revista del Instituto de Defensa del Café* of Costa Rica.

The process became generally known, and was found to be a most advantageous proposition in the big plantation industries — coffee, tea, sugar, maize, tobacco, sisal, rice, and vine — yields and quality alike being notably improved. I devoted my energies to advising and assisting those interested, and during this period, became greatly indebted to the tea industry for material help and encouragement.

In 1937, results were reported in the case of tea which were difficult to explain. Single light dressings of Indore compost improved the yield of leaf and increased the resistance of the bush to insect attacks in a way which much surpassed what was normally to be expected from a first application. While considering these cases, I happened to read an account of Dr Rayner's work on conifers at Wareham in Dorsetshire, where small applications of humus had also produced spectacular results.

Normally humus is considered to act on the plant indirectly: the oxidation of the substances composing it form salts in the soil, which are then absorbed by the root hairs in the usual process of nutrition. Was there here, however, something more than this — some direct action having an immediate and powerful effect?

Such indeed has proved to be the case, and the explanation can now be set forth of the wonderful double process by which Nature causes the plant to draw its sustenance from the soil. The mechanism, by which living fungal threads (mycelium) invade the cells of the young roots and are gradually digested by these, is described in detail in *Chapter 2, The Living Soil*. It was this, the mycorrhizal association, which was the explanation of what had happened to the conifers and the tea shrubs. Both are forest plants, a form of vegetation in which this association of root and fungus has been known for a long time. This *direct* method of feeding would account for the results observed.

A number of inquiries which I was now able to undertake revealed the existence of this natural feeding mechanism in plant after plant, where it had until now been neither observed nor looked for — *but it only occurred where there was ample humus in the soil*. Where humus was wanting, the mechanism was either absent or ineffective, and the plant was limited to the sustenance derived from absorption of the salts in the soil solution: it could not draw on these rich living threads, abounding in protein.

The importance of the opening up of this aspect of plant nutrition was quite obvious. Here, at last, was a full and sufficient explanation of the facts governing the health of plants. From this point on, evidence began to accumulate to illumine the new path of inquiry — which in my opinion is destined to lead us a very long way indeed.

It was clear that the doubling of the processes of plant nutrition was one of those reserve devices on which rests the permanence and stability of Nature. Plants deprived of the mycorrhizal association continue to exist, but they lose both their power to resist shock and their capacity to reproduce themselves. A new set of facts suddenly fell into place: the running out of varieties, a marked phenomenon of modern agriculture which requires that new varieties of crops constantly need to be bred — hence the modern plant breeding station — could without hesitation be attributed to the continued impoverishment of modern soils owing to the prolonged negligence of the Western farmer to feed his fields with humus.

By contrast, the maintenance of ancient varieties in the East, so old that in India they bear ancient Sanskrit names, was proof of the unimpaired capacity of the plant to breed in those countries where humus was abundantly supplied.

The mycorrhizal association may not prove to be the only path by which the nitrogen complexes derived from the digestion of proteins reach the sap. Humus also nourishes countless millions of bacteria whose dead bodies leave specks of protein thickly strewn throughout the soil. But these complex bodies are not permanent: they are reduced by other soil organisms to simpler and simpler bodies which finally become mineralised to form the salts taken up by the roots for use in the green leaves.

Is it possible that some of the very early stages in the oxidation of these specks of protein are absorbed by the root hairs from the soil water? It would seem so, because a few crops exist, such as the tomato, which, although reacting to humus, are not provided with the mycorrhizal association. This matter is discussed in the next chapter.

These results set up a whole train of thought. The problem of disease and health took on a wider scope, and in March 1939, new ground was broken.

The local Medical and Panel Committees of Cheshire, summing up their experience of the working of the *National Health Insurance Act* for over a quarter of a century in the county, did not hesitate to link the unsatisfactory state of health of the human population under their care with the problem of nutrition. They traced the problem right back to an impoverished soil, and supported their contentions with reference to the ideas which I had for some time been advocating (see *Medical Testament*.) Their arguments were powerfully supported by the results obtained at the Peckham Health Centre and by the work, already published, of Robert McCarrison, who told the story from the other side of the world and from a precisely opposite angle; he documented an Eastern people, the Hunzas, who were the embodiment of the ideal of health, and whose food was derived from soil kept in a state of the highest natural fertility.

By these contemporaneous pioneering efforts, the way was blazed for treating the entire problem of health in soil, plant, animal, and man as one great subject, calling for a boldly revised point of view, and entirely fresh investigations.

By this time, sufficient evidence had accumulated to set out the case for soil fertility in book form. This was published in 1940 by the Oxford University Press under the title of *An Agricultural Testament*. This book, now in its fourth English and second American editions, sets forth the whole gamut of connected problems as far as is presently possible.

In it, I summarised my life's work, and advanced the following views.

1. The birthright of all living things is health.
2. This law is true for soil, plant, animal, and man: the health of these four is one connected chain.
3. Any weakness or defect in the health of any earlier link in the chain is carried on to the next and succeeding links, until it reaches the last — man.
4. The widespread vegetable and animal pests and diseases, which are such a bane to modern agriculture, are evidence of a great failure of health in the second (plant) and third (animal) links of the chain.
5. The impaired health of human populations (the fourth link) in modern civilised countries is a consequence of this failure in the second and third links.
6. This general failure in the last three links is to be attributed to failure in the first link, the soil: *the undernourishment of the soil is at the root of all.* The failure to maintain a healthy agriculture has largely cancelled out all the advantages we have gained from our improvements in hygiene, in housing, and our medical discoveries.
7. To retrace our steps is not really difficult if we set our minds to the problem. We have to bear in mind Nature's dictates, and we must obey her demands for:

   a) the return of all wastes to the land;

   b) the combination of animal and vegetable existence;

   c) the maintaining of an adequate reserve system of feeding the plant, i.e. we must not interrupt the mycorrhizal association.

If we are willing to conform to these natural laws, we shall rapidly reap great rewards — not only in a flourishing agriculture, but also in the immense asset of an abounding health, in both ourselves and in our children's children.

These ideas, straightforward as they appear when listed in the form given above, conflict with a number of vested interests. It has been my self-appointed task during the last few years to work with those who are convinced of their truth to fight the forces impeding progress. So large has been the flow of accumulating evidence that in 1941 it was decided to publish a *Newsletter on Compost*, containing the most interesting of the facts and opinions reaching me or others in the campaign. The newsletter, which appears three times a year under the aegis of the Cheshire Local Medical and Panel Committees, has grown from eight to 64 pages, and is constantly gaining new readers.

The general thesis — *that no single generation has the right to exhaust the soil from which humanity must draw its sustenance* — has received further powerful support from religious bodies. The clearest exposition of this idea is contained in one of the five fundamental principles adopted by the recent Malvern Conference of Christian Churches held with the support of the late Archbishop of Canterbury, Dr Temple:

> "The resources of the earth should be used as God's gifts to the whole human race and used with due consideration for the needs of the present and future generations."

Food is the chief necessity of life. The plans for social security which are now being discussed merely guarantee to the population a share in a variable and, in present circumstances, an uncertain quantity of food, most of it of doubtful quality. Real security against want and ill health can be assured only by an abundant supply of fresh food properly grown in soil in good health.

The first place in plans of reconstruction must be given to soil fertility in every part of the world. The land of this country and the Empire, which is the direct responsibility of Parliament, must be raised to a higher level of productivity by a rational system of farming which puts a stop to the exploitation of land for the purpose of profit, and takes into account the importance of humus in producing food of good quality. The electorate alone has the power of enforcing this, and to do so, it must first realise the full implications of the problem.

They, and they alone, possess the power to insist that every boy and every girl shall enter into their birthright — health — and the efficiency, well-being, and contentment which depend on it. One of the objects of this book is to show the man and woman in the street how this England of ours can be born again. They can help in this task, which depends at least as much on the plain and simple efforts of ordinary citizens on their own farms, gardens, or allotments as on all the expensive paraphernalia, apparatus, and elaboration of modern science — more so in all probability, inasmuch as one small example always outweighs a ton of theory.

If this sort of effort can be made and the main outline of the problems at stake are grasped, nothing can stop an immense advance in the well-being of this island. A healthy population will be no mean achievement, for our greatest possession is ourselves.

The man in the street will have to do three things:

1. He must create in his own farm, garden, or allotment examples, without end, of what a fertile soil can do.
2. He must insist that the public meals in which he is directly interested, such as those served in boarding schools, in the canteens of schools and factories, in popular restaurants and tea shops, and at the seaside resorts at which he takes his holidays, are composed of the fresh produce of fertile soil.

3. He must use his vote to compel all his various representatives to see to it that:
   a) the soil of this island is made fertile and maintained in this condition; and
   b) the public health system of the future is based on the fresh produce of land in good health.

This introduction started with the training of an agricultural investigator: it ends with the principles underlying the public health system of tomorrow. It has, therefore, covered much ground in describing what is nothing less than a great adventure in scientific research.

One lesson must be stressed. The difficulties met with and overcome in the official portion of this journey were not part of the subject investigated. They were man-made and created by the research organisation itself. More time and energy had to be expended in side-tracking the lets and hindrances freely strewn along the road by the various agencies which controlled discovery than in conducting the investigations themselves.

When the day of my retirement arrived, all these obstacles vanished and the delights of complete freedom were enjoyed. Progress was instantly accelerated. Results were soon obtained throughout the length and breadth of the English-speaking world, which make crystal clear the great role which soil fertility must play in the future of mankind.

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I

Soil Fertility and Agriculture

1.1 THE OPERATIONS OF NATURE

The introduction to this book describes an adventure in agricultural research and records the conclusions reached. If the somewhat unorthodox views set out here are sound, they will not stand alone, but will be supported and confirmed in a number of directions — by the farming experience of the past, and above all by the way Nature, the supreme farmer, manages her kingdom.

In this chapter, the manner in which various natural operations function will be briefly reviewed. In surveying the significant characteristics of the life — vegetable and animal — met with in Nature, particular attention will be paid to the importance of fertility in the soil, and to the occurrence and elimination of disease in plants and animals.

What is the character of life on this planet? What are its great qualities? The answer is simple. The outstanding characteristics of Nature are *variety* and *stability*.

The *variety* of the natural life around us is such as to strike even the imagination of children, when they see in the fields and copses near their homes, in the ponds and streams and seaside pools round which they play — or if, as a consequence of living in the city, they are deprived of these delightful playgrounds, even in their back yards or in the neighbouring park, there will be an infinite choice of different flowers and plants and trees, coupled with an animal world full of rich changes and surprises. In fact, there is readily found a plenitude of the forms of living things that constitutes a powerful introduction into the nature of the universe, of which we ourselves are a part.

The infinite variety of forms visible to the naked eye is carried much farther by the microscope. When, for example, the green slime in stagnant water is examined, a new world is disclosed — a multitude of simple flowerless plants — the blue-green and the green algae — always accompanied by the lower forms of animal life. We shall see in a later chapter (*Chapter 8, Rice*) that on the operations of these green algae, the well-being of the rice crop, which nourishes countless millions of the human race, depends.

If a fragment of mouldy bread is suitably magnified, members of still another group of flowerless plants, made up of fine, transparent threads entirely devoid of green colouring matter, come into view. These belong to the fungi, which are of supreme importance in farming and gardening.

It needs a more refined perception to recognise throughout this stupendous wealth of varying shapes and forms the principle of *stability*. Yet this principle dominates. It dominates by means of an ever-recurring cycle, a cycle which, repeating itself silently and ceaselessly, ensures the continuation of living matter. This cycle is constituted of the successive and repeated processes of birth, growth, maturity, death, and decay.

Buddhism calls this cycle 'the Wheel of Life', and no better name could be given to it. The revolutions of this Wheel never falter and are perfect. Death supersedes life, and life rises again from what is dead and decayed.

Because we are ourselves alive, we are much more conscious of the processes of growth than we are of the processes involved in death and decay. This is perfectly natural and justifiable. Indeed, it is a powerful instinct in us, and a healthy one.

Yet, if we are fully grown human beings, our education should have developed in us the ability to grasp intelligently the vast role played in the universe by the processes making up the other, or more hidden, half of the Wheel. In this respect, however, our general education in the past has been gravely defective, partly because science itself has so sadly misled us. Those branches of knowledge dealing with the vegetable and animal kingdoms — botany and zoology — have confined themselves almost entirely to a study of living things, and have given little or no attention to what happens to these units of the universe when they die and to the way in which their waste products and remains affect the general environment on which both the plant and animal worlds depend. When science itself is unbalanced, how can we blame education for omitting in her teaching one of the things that really matter?

For though the phases which are preparatory to life are, as a rule, less obvious than the phases associated with the moment of birth and the periods of growth, they are not less important. If we can grasp this, and think in terms of ever-repeating advance and recession, recession and advance, we have a truer view of the universe than if we define death merely as an ending of what has been alive.

Nature herself is never satisfied, except by an even balancing of her processes — growth and decay. It is precisely this even balancing which gives her absolute stability. That stability is rock-like. Indeed, this figure of speech is a poor one, for the stability of Nature is far more permanent than anything we can call a rock — rocks being creations which themselves are subject to the great stream of dissolution and rebirth, seeing that they suffer from weathering and are formed again, that they can be changed into other substances and caught up in the grand process of living: they too, as we shall see (in *Chapter 7*), are part of the Wheel of life.

However, we may at a first glance omit the changes which affect the inert masses of this planet, petrological and mineralogical: though very soon we shall realise how intimate is the connection even between these and what is, in the common parlance, alive. There is a direct bridge between things inorganic and things organic, and this too is part of the Wheel.

But before we start on our examination of that part of the great process which now concerns us — namely, plant and animal life, and the use man makes of them — there is one further idea which we must consider.

It is this. The stability of Nature is secured not only by means of an even balancing of her Wheel, by a perfect timing, so to say, of her mechanisms — but it also rests on a foundation of enormous reserves. Nature is never a hand-to-mouth practitioner. She is often called lavish and wasteful, and at first sight one can be bewildered and astonished at the apparent waste and extravagance which accompany the carrying on of vegetable and animal existence.

Yet a more exact examination shows her working with an assured background of accumulated reserves, which are stupendous and also essential. The least depletion in these reserves brings about vast changes, and not until she has built them up again does she resume the particular process on which she was engaged.

A realisation of this principle of reserves is thus a further necessary item in a wide view of natural law. Anyone who has recovered from a serious illness, during which the human body lives partly on its own reserves, will realise how Nature afterwards deals with such situations. During the period of convalescence, the patient appears to make little progress until suddenly he resumes his old-time activities. During this waiting period, the reserves used up during illness are being replenished.

The life of the plant

A survey of the Wheel of Nature will best start from that rather rapid series of processes which cause what we commonly call 'living matter' to come into active existence — that is, in fact, the point at which life most obviously, to our eyes, begins. The section of the Wheel embracing these processes is studied in the discipline of physiology (from the Greek root *phuein*, 'to bring to life, to grow').

But how does life begin on this planet? We can only say this: that the prime agency is sunlight, because it is the source of energy; and that the instrument for intercepting this energy and making use of it is the green leaves of plants.

This wonderful little example of Nature's invention is a battery of intricate mechanisms. Each cell in the interior of a green leaf contains minute specks of a substance called chlorophyll, and it is this which enables the plant to grow.

Growth implies a continuous supply of nourishment. Now, plants do not merely collect their food: they manufacture it before they can feed. In this, they differ from animals and man, who search for what they can pass through their stomachs and alimentary systems, but cannot do more; if they are unable to find what is suitable to their natures and ready for them, they perish.

A plant, on the other hand, is in a way a more wonderful instrument. It is an actual food factory, making what it requires before it begins the processes of feeding and digestion. The chlorophyll in the green leaf, with its capacity for intercepting the energy of the sun, is the power unit that runs the machine. The green leaf allows the plant to draw simple raw materials from diverse sources, and to transform them into complex combinations.

Thus from the air it absorbs carbon dioxide (a compound of two parts of oxygen to one of carbon), which is combined with more oxygen from the atmosphere and with other substances, both living and inert, drawn from the soil, and from the water which permeates the soil.

All these raw materials are then assimilated in the plant, and made into food. They become organic compounds, i.e. compounds of carbon, classified conveniently into groups known as carbohydrates, proteins, and fats. Together with an enormous volume of water (often over 90 per cent of the whole plant) and interspersed with small quantities of chemical salts which have not yet been converted into the organic phase, they make up the structure of the plant — root, stem, leaf, flower, and seed.

This structure includes a large food reserve. The life principle, the true nature of which evades us and in all probability always will, resides in the proteins in the mass. These proteins carry on their work in a cellulose framework made up of cells protected by an outer integument and supported by a set of structures known as the vascular bundles, which also conduct the sap from the roots to the leaves, and distribute the food manufactured there to the various centres of growth. The whole of the plant structures are kept turgid by means of water.

The green leaf, with its chlorophyll battery, is therefore a perfectly adapted agency for continuing life. It is, speaking plainly, the only agency that can do this, and is unique. Its efficiency is of supreme importance. Because animals, including man, feed eventually on green vegetation, either directly or through the bodies of other animals, it is ultimately our sole and final source of nutriment.

There is no alternative supply. *Without sunlight and the capacity of the earth's green carpet to intercept its energy for us, our industries, our trade, and our possessions would soon be useless.* It follows, therefore, that everything on this planet must depend on the way mankind makes use of this green carpet; in other words, on its *efficiency*.

The green leaf does not, however, work by itself. It is only a part of the plant. It is curious how easy it is to forget that normally we see only half of each flowering plant, shrub, or tree — the rest is buried in the ground. Yet the dying down of the visible growth of many plants in the winter, and their quick reappearance in the spring, should teach us how an essential and important portion of all vegetation lives out of our sight; it is evident that the root system, buried in the ground, also holds the life of the plant in its grasp. It is therefore not surprising to find that leaves and roots work together, forming a partnership which must be put into fresh working order each season if the plant is to live and grow.

If the function of the green leaf armed with its chlorophyll is to manufacture the food the plant needs, the purpose of the roots is to obtain the water and most of the raw materials required — the sap of the plant being the medium by which these raw materials (collected from the soil by the roots) are moved to the leaf. The work of the leaf we found to be intricate: that of the roots is just as complex.

What is surprising is to discover the two quite distinct ways in which the roots set about collecting the materials which it is their business to supply to the leaf; these two methods are carried on simultaneously. We can make a very shrewd guess at the master principle which has put the second method alongside the first: it is again the principle of providing a reserve — this time of the vital proteins.

None of the materials that reach the green leaf by whatever method is food: it is only the raw stuff from which food is to be manufactured.

By the first method, which is the most obvious one, the root hairs search out and pass into the transpiration current of the plant dissolved substances which they find in the thin films of water spread between and around each particle of earth; this film is known as the *soil solution*. The substances dissolved in it include gases (mainly carbon dioxide and oxygen) and a series of other substances known as chemical salts such as nitrates, compounds of potassium and phosphorus, and so forth — all obtained by the breaking down of organic matter or from the destruction of the mineral components of the soil. In this breaking down of organic matter, we see in operation the reverse of the constructive process which takes place in the leaf.

Organic matter is continuously reverting to the inorganic state: it becomes mineralised: nitrates are one form of the outcome. It is the business of the root hairs to absorb these substances from the soil solution and to pass them into the sap, so that the new life-building process can start up again.

In a soil in good health, the soil solution will be well supplied with these salts. Incidentally we may note that it has been the proved existence of these mineral chemical constituents in the soil which, since the time of Liebig, has focused attention on soil chemistry, and has emphasised the passage of chemical food materials from soil to plant, to the neglect of other considerations.

But the earth's green carpet is not confined merely to its remarkable power of transforming the inert nitrates and mineral contents of the soil into an active organic phase.

Plants also establish for themselves a direct connection, a kind of living bridge, between themselves and the living portion of the soil. This is the second method by which plants feed themselves.

The importance of this process, physiological in nature and not merely chemical, cannot be over-emphasised and some description of it will now be attempted.

The living soil

The soil is full of live organisms. It is essential to understand it as something pulsating with life, not as a dead or inert mass. There could be no greater misconception than to regard the earth as dead: a handful of soil is teeming with life. The living fungi, bacteria, and protozoa, invisibly present in the soil complex, are known as the soil population.

This population of millions upon millions of minute existences, quite invisible to our eyes of course, pursue their own lives. They come into being, grow, work, and die: they sometimes fight each other, they win victories, or they perish; for they are divided into groups and families adapted to exist under all sorts of conditions. The state of a soil will change with the victories won or the losses sustained, and in one or other soil, or at one or other moment, different groups will predominate.

This lively and exciting life of the soil is the first thing that sets in motion the great Wheel of Life. Not without truth have poets and priests paid worship to Mother Earth, the source of our being. What poetry or religion have vaguely celebrated, science has minutely examined, and increasingly complete descriptions now exist of the character and nature of the soil populations, the various species of which have been classified, labelled, and observed. It is this life which is continually being passed into the plant.

The process can actually be followed under the microscope. Some of the individuals belonging to one of the most important groups in this mixed population — the soil fungi — can be seen functioning. If we arrange a vertical darkened glass window on the side of a deep pit in an orchard, it is not difficult to see with the help of a good lens or a low-power horizontal microscope (arranged to travel up and down a vertical fixed rod) some of these soil fungi at work. They are visible in the interstices of the soil as glistening white branching threads, reminiscent of cobwebs.

In Dr Rogers's interesting experiments on the root systems of fruit trees at East Malling Research Station, where this method of observing them was initiated and demonstrated to me, these fungal threads could be seen approaching the young apple roots in the absorbing region (just behind the advancing root tips) on which the root hairs are to be found.

Dr Rogers very kindly presented me with two photographs — one showing the general arrangement of his observation chamber (*Figure 1*); the other, taken in July 1933, of a root tip (magnified about 12x) of Lane's Prince Albert apple at sixteen inches below the surface, shows abundant fungal strands running in the soil and coming into direct contact with the growing root (*Figure 2*).

Figure 1. Dr Rogers' observation chamber

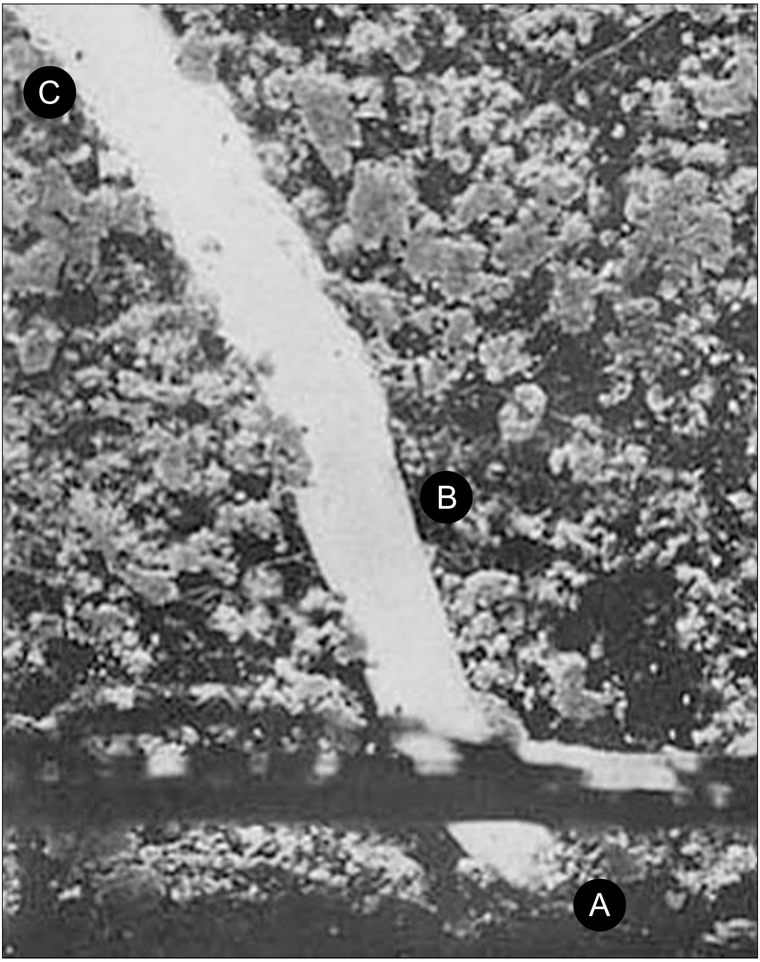

Figure 2. The beginnings of mycorrhizal association in the apple. Root-tip (x12) of Lane's Prince Albert at sixteen inches below the surface, showing root-cap (A), young root hairs (B), and older root hairs with drops of exudate (C). The cobweb-like mycelial strands are well seen approaching the rootlet in the region marked (B).

But this is only the beginning of the story. When a suitable section of one of these young apple roots, growing in fertile soil and bearing active root hairs, is examined, it will be found that these fine fungal threads actually invade the cells of the root, where they can easily be observed passing from one cell to another. But they do not remain there very long. After a time, the apple roots absorb these threads. All stages of the actual digestion can be observed.

The significance of this process needs no argument. Here we have a simple arrangement on the part of Nature by which the soil material on which these fungi feed can be joined up, as it were, with the sap of the tree. These fungal threads are very rich in protein, and may contain as much as 10 per cent of organic nitrogen; this protein is easily digested by the ferments (enzymes) in the cells of the root. The resulting nitrogen complexes, which are readily soluble, are then passed into the sap current, and so into the green leaf. An easy passage, as it were, has been provided for food material to move from soil to plant in the form of proteins and their digestion products, which latter in due course reach the green leaf.

The marriage of a fertile soil and the tree it nourishes is thus arranged. Science calls these fungal threads *mycelium* (from the Greek), and as the Greek for root is *rhiza*, cf. *rhizome*, the whole process is known as the *mycorrhizal association.*

The reader who wishes to delve into the technical details relating to the mycorrhizal association and its bearing on forestry and agriculture should consult the following works:

— *Problems in Tree Nutrition,* Rayner & Neilson-Jones,
Faber & Faber, London, 1944.

— *The Living Soil*, Eve Balfour,
Faber & Faber, London, 1944.

— *An Agricultural Testament,* Albert Howard,
Oxford Press, 1940.

What is urgently needed is an account — in simple, non-technical language — of this remarkable link between a fertile soil and the roots of the vast majority of flowering plants, and its significance in nutrition and disease resistance.[1]

This partnership is universal in the forest, and is general throughout the vegetable kingdom. However, exceptions exist.

Among the plants in which this mycorrhizal association has *not* been observed are the tomato and certain members of the cabbage family, many of which possess a diffuse root system, and exceptionally elongated root hairs. Nevertheless, these examples respond markedly to the condition of the soil in which they are grown, and if fed with dressings of humus, they prosper.

The question naturally arises: exactly *how* does this take place? What is the alternative mechanism that replaces the absent mycorrhizal association?

A simple explanation would appear to be this. Fertile soils invariably contain a greatly enhanced bacterial population whose dead remains must be profusely scattered in the water films which bathe the compound soil particles and the root hairs of the crops themselves; these specks of dead organic matter, rich in protein, are finally mineralised into simple salts such as nitrates.

We have already mentioned this breaking-down process of the soil population. What should be noted here is that it is no sudden transformation, but takes place in stages. Could it be, therefore, that some of the first-formed nitrogen complexes, which result from this breaking down, are absorbed by the root hairs and so added to the sap current?

That is to say that the non-mycorrhiza-forming plants, not drawing on the soil fungi, compensate themselves by absorbing organic nitrogen in this form — they catch the bacterial soil population, as it were, before it has been

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1. See *Trees and Toadstools*, M. Rayner, 1945

reduced to an entirely inert phase — and so they have their own link with the biological life of the soil.

That there must be some such passage of matter on a biological basis is suggested by the fact that only in fertile soil, i.e. in soils teeming with bacteria, do these non-mycorrhiza formers reveal resistance to disease and high quality in the produce — which means that only in these soils are they really properly fed.

This would be a third method used by plants for feeding themselves, a sort of half-way method between the absorption powers exercised by the root hairs and the direct digestive capacity of the roots: as the mechanism used in this method is presumably the root hairs, the diffuseness of the root system of plants of the cabbage family would be explained. It is possible that even mycorrhiza formers use this alternative passage for organic nitrogen. There seems no reason at all why this should not be so.

But how do the various agencies concerned in these intricate operations manage to carry on their work, buried as they are away from the light and thus unable to derive anything from the primal source of energy, the sun? How do they do their initial work at all, until they can hand over to the green leaf?

They derive their energy by oxidising (i.e. burning up) the stores of organic matter in the soil. As in an ordinary fire, this process of oxidation releases energy. The oxygen needed for this slow combustion is drawn from the air, in part washed down by the rain, which leaches it from the atmosphere as it descends.

This explains why rainwater is so superior as a moistening agency for plants, compared to any form of watering from a can: incidentally, again, we can understand the need for cultivating the soil and keeping it open, so that the drawing in of oxygen, or the respiration of the soil, can proceed and the excess carbon dioxide can be expelled into the atmosphere.

Humus is the Latin word for 'soil' or 'earth'. But 'humus' nowadays does not mean just 'earth' in general, but indicates that undecayed residue of vegetable and animal waste lying on the surface, combined with the dead bodies of the bacteria and fungi themselves when they have done their work — the whole being a highly complex and varying mixture which is, in a sense, the store or bank from which the organisms of the soil and then, in direct succession, the plant, the tree, and thereafter the animal, draw what they need for their existence. This store is all important.

The significance of humus

Humus is the most significant of all Nature's reserves, and as such deserves a detailed examination.

A perfect example of the methods by which Nature makes humus and thus initiates the turning of her Wheel is provided by the floor of the forest.

Dig down idly with a stick under any forest tree: first there will be a rich, loose, accumulation of litter made up of dead leaves, flowers, twigs, fragments of bark, bits of decaying wood, and so forth, turning gradually, as the material becomes more tightly packed, into rich, moist, sweet-smelling earth, which continues downwards for some inches and which, when disturbed, reveals many forms of tiny insect and animal life. We have been given here a glimpse of the way Nature makes humus — the source from which the trunk of the tree has drawn its resisting strength, and its leaves their glittering beauty.

Throughout the year, endlessly and continuously, though faster at some seasons than at others, the wastes of the forest thus accumulate and undergo transformation. These wastes are of many kinds, and they mix as they fall; leaf mingles with twig and stem, flower with moss, and bark with seed coats.

Moreover, vegetable mingles with animal. Let us beware of the false idea that the forest is a part of the vegetable kingdom only. Millions of animal existences are housed in it; mammals and birds are everywhere and can be seen with the naked eye.

The lower forms of animal life — the invertebrates — are even more numerous. Insects, earthworms, and so forth are obvious: the microscope reveals new worlds of animal life down to simple protozoa. The excretions of these animals while living, and their dead bodies, constitute an important component of what lies on the forest floor; even the bodies of insects form in the mass a constituent element not without importance, so that in the end the two sources of waste are completely represented and are, above all, completely mingled. But the volume of the vegetable wastes is several times greater than that of the animal residues.

These wastes lie gently, disturbed only by wind or by the footfall of passing animals. The top layer is thus very loose; ample air circulates for several inches downwards: the conditions for the fermentation by the moulds and microbes (which feed on the litter) are, as the scientist would say, *aerobic*.

But partly by pressure from above and partly as the result of fermentation, the lower layers are forced to pack more closely and the final manufacture of humus goes on without much air: the conditions are now *anaerobic*.

This is a succession of two modes of manufacture which we shall do well to remember, as it has to be imitated in our practical work (See *Chapter 13, The New Zealand Compost Box*).

This mass of accumulated wastes is acted on by the sunlight and the rain; both are dispersed and fragmented by the leaf canopy of the trees and undergrowth. The sunlight warms the litter; the rain keeps it moist. The rain does not reach the litter as a driving and damaging sheet, but is split up into small drops, the impetus of whose fall is well broken. Nor does the sunlight burn without shade; it is tempered. Finally, though air circulates freely, there is perfect protection from the cooling and drying effects of strong wind.

With abundant air, warmth, and water at their disposal, the fungi and bacteria, with which, as we have already noted, the soil is teeming, do their work. The fallen mixed wastes are broken up; some passes through the bodies of earthworms and insects: everything is imperceptibly crumbled and changed until it decomposes into that rich mass of dark colour and earthy smell which is so characteristic of the forest floor, and which holds such a wealth of potential plant nourishment.

The process that takes place in a prairie, a meadow, or a steppe is similar, although perhaps slower, and the richness of the layer of humus will depend on a good many factors.

One, in particular, has an obvious effect — the supply of air. If, for some reason, this is cut off, the formation of humus is greatly impeded. Areas, therefore, that are partly or completely waterlogged will not form humus as the forest does: the upper portion of the soil will not have access to sufficient free oxygen, nor will there be much oxygen in the standing water. In the first case a moor will result; in the second a bog or morass will be formed. In both these, the conditions are anaerobic: the organisms derive their oxygen not from the air, but from the vegetable and animal residues including the proteins. In this fermentation, nitrogen is always lost and the resulting low-quality humus is known as *peat*.

But the forest, the prairie, the moor, and the bog are not the only areas where humus formation is in progress. It is constantly going on in the most unlikely places — on exposed rock surfaces, on old walls, on the trunks and branches of trees, and indeed wherever the lower forms of plant life — algae, lichens, mosses, and liverworts — can live and then slowly build up a small store of humus.

Nature, in fact, conforming to the principle of reserves, does not attempt to create the higher forms of plant life until she has secured a good reserve of humus. Watch how the small bits of decayed vegetation fall into some crack in the rock and decompose: here is the little fern, the tiny flower, secure of its supply of food and well able to look after itself, as it thrusts its roots down into the rich pocket of nourishment.

Nature adapts her flora very carefully to her varying supplies of humus. The plant above is the indicator of what the soil below is like, and a trained observer, sweeping his eye over the countryside, will be able to read it like the pages of a book, and to tell without troubling to cross a valley exactly where the ground is waterlogged, where it is accumulating humus, and where it is being eroded. He looks at the kind and type of plant, and infers from their species and condition the nature of the soil which they simultaneously cover and reveal.

But we are not yet at the end of the mechanisms employed by Nature to get her great Wheel to revolve with smooth efficiency. The humus that lies on the surface must be distributed and made accessible to the roots of plants and especially to the absorbing portions of the roots and their tiny prolongations known as root hairs — for it is these which do the delicate work of absorption.

How can this be done? Nature has, perforce, laid her accumulations on the surface of the soil. But she has no fork or spade: she cannot dig a trench and lay the food materials at the bottom, where the plant root can strike down and get them. It seems an impasse, but the solution is, again, curiously simple and complete.

Nature has her own labour force — ants, termites, and, above all, earthworms. These carry the humus down to the required deeper levels, where the thrusting roots can have access to it.

This distribution process goes on continually, varying in intensity with night and day, with wetness or dryness, heat or cold, which alternately bring the worms to the surface for fresh supplies, or sends them down into the depths. It is interesting to note how a little heap of leaves in the garden disappears in the course of a night or two when the earthworms are actively at work. The mechanism of humus distribution is a give and take, for where a root has died the earthworm or the termite will often follow the minute channel thus created.

Actually, the earthworm eats the humus and the soil and passes them through its body, leaving behind the casts which are really enriched earth — perfectly conditioned for use by plants. Analyses of these casts show that they are some 40 per cent richer in humus than the surface soil, but also very much richer in such essential food materials as nitrogen, phosphate, and potash.

Recent results obtained by Lunt and Jacobson of the Connecticut experimental station show that the casts of earthworms are five times richer in combined nitrogen, seven times richer in available phosphate, and eleven times richer in potash, than the upper six inches of soil.

It is estimated that on each acre of fertile land no less than 25 tons of fresh worm casts are deposited each year. Besides this, the dead bodies of the earthworms make an appreciable contribution to the supply of manure. In these ways Nature in her farming has arranged that the earth itself shall be her manure factory.

As the humus is continually being created, so it is also being used up. Not more than a certain depth accumulates on the surface, normally anything from a few inches to two or three feet. After a time, the process ceases to be additive and becomes simply continuous: the growing plants consume the product at a rate equalling the rate of manufacture.

This is the even turning of the Wheel of Life — the perfect example of balanced manuring. A reserve, however, is at all times present, and on virgin and undisturbed land, it may be very great indeed. This is an important asset in man's relationship with the environment; we shall later see how important.

The importance of minerals

Is the humus the only source from which the plant draws its nourishment? No. The subsoil, i.e. that part of the soil derived from the decay of rocks, which lies below the layer of humus, also has its part to play. The subsoil is, as it were, a depository of raw material. It may be of many types — clay, sand, etc. — the geological formation will vary widely. It always includes a mineral content — potash, phosphates, and many rarer elements.

Now these minerals play an important part in the life of living things. They have to be conveyed to us in our food in an organic form, and it is from the plant, which transforms them into an organic phase and holds them thus, that we and the other animals derive them for our well-being.

How does the plant obtain them? We have seen that there is a power in the roots of all plants — even the tiniest — of absorbing minerals from the soil solution. But how is the soil solution itself impregnated with these substances?

It is achieved mainly through the dissolving power of the water in the soil, which contains carbon dioxide in solution, and so acts as a weak solvent. It would appear that the roots of trees, as they thrust down into the subsoil, draw on the dissolved mineral wealth stored there, and absorb the minerals into their structure. In tapping the lower levels of water present in the subsoil — for trees are like great pumps drawing at a deep well — they also tap the minerals dissolved therein. These minerals are then passed into all parts of the tree, including the foliage.

In the autumn, the foliage decays and falls, and the stored minerals, now in an organic phase, are also dropped and become available on the top layers of the soil: they become incorporated in the humus.

This explains the importance of leaf-fall in preserving the land in good health, and is one reason why gardeners love to accumulate leaf-mould. By this means, they feed their vegetables, fruit, and flowers with the minerals they need.

The tree has acted as a great circulatory system, and its importance in this direction is to be stressed. The destruction of trees and forests is therefore most injurious to the land, for not only are the physical effects harmful — the anchoring roots and the sheltering leaf canopy being alike removed — but the necessary circulation of minerals is put out of action.

It is at least possible that the present mineral poverty of certain tracts of the earth's surface, e.g. on the South African *veldt*, is due to the destruction over wide areas and for long periods of all forest growth, both by the wasteful practices of indigenous tribes, and more recently by exploiting Western interests.

Summary

Before we turn to consider the ways in which man has delved and dug into all these riches and disturbed them for his own benefit, let us take a final look at the operations of Nature.

Perhaps one fact will strike us as symptomatic of what we have been discussing: namely, that enormous care is bestowed by Nature on the processes both of *destruction* and of *storage*.

She is as minute and careful, as generous in her intentions, and as lavish, in breaking down what she has created as she was originally in building it up. The subsoil is called upon for some of its water and minerals, the leaf has to decay and fall, the twig is snapped by the wind, the very stem of the tree must break, lie, and gradually be eaten away by minute vegetable or animal agents; these in turn die, their bodies are acted on by quite invisible fungi and bacteria; these also die, they are added to all the other wastes, and the earthworm or ant begins to carry this accumulated reserve of earthly decay away. This material — humus — is the very beginning of vegetable life, and therefore of animal life, and of our own being. Such care, such intricate arrangements are surely worth studying, as they are the basis of all Nature's farming and can be summed up in a phrase — *the Law of Return.*

We have thus seen that one of the outstanding features of Nature's farming is the care devoted to the manufacture of humus and to the building up of a reserve. What does she do to control such things as insects, fungal diseases, and virus diseases in plants, and the various afflictions of her animal kingdom? What provision is to be found for plants' protection or for checking the diseases of animals? How is the work of mycologists, entomologists, and veterinarians done by Mother Earth? Is there any special method of dealing with diseased material such as destruction by fire?

For many years, I have diligently searched for some answer to these questions, or for some light on these matters. My quest has produced only negative evidence. There appears to be no special natural provision for controlling pests, for the destruction of diseased material, or for protecting plants and animals against infection. All manner of pests and diseases can be found here and there in any wood or forest; the disease-infected wastes find their way into the litter and are duly converted into humus. Methods designed for the protection of plants and animals against infection do not appear to have been provided. It would seem that the provision of humus is all that Nature needs to protect her vegetation; and, nourished by the food thus grown, in due course the animals also look after themselves.

In their survey of world agriculture — past and present — surely the various schools of agricultural science might be expected to include these operations of Nature in their teaching.

But when we examine the syllabuses of these schools, we find hardly any references to this subject, and nothing whatever approximating to the great Law of Return.

The great principle underlying Nature's farming has been ignored. In fact, it has been flouted — and the cheapest and quickest methods of transferring the reserves of humus (left by the prairie and the forest) to the profit and loss account of *homo sapiens* have been stressed instead.

There is, in short, something wrong with our agricultural practices and our education system.

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1.2 SYSTEMS OF AGRICULTURE

What is agriculture?

It is undoubtedly the oldest of the great arts; its beginnings are lost in the mists of man's earliest days.

Moreover, it is the foundation of settled life — and therefore of all true civilisation — for until man had learnt to add the cultivation of plants to his knowledge of hunting and gathering, he could not emerge from his savage existence. This is no mere surmise: observation of surviving primitive tribes, still in the hunting and gathering stage such as the Bushmen and Hottentots of Africa, show them unable to progress, because they have not mastered and developed the principle of cultivation of the soil.

Primitive forms of agriculture

The earliest forms of agriculture were simple processes of gathering or reaping. Man waited until Nature had perfected the fruits of the earth, and then seized them for his own use. It was a kind of banditry.

It is to be noted that what is intercepted is often some form of Nature's storage of reserves; most especially, most ripe seeds are the perfect arsenals of natural reserves.

Interception may, however, take other forms. A well-developed example of human existence based on a technique of interception is the nomadic pastoral tribe. Pastoral peoples are found all over the world; they have played a big part in the history of the human race, and often exhibit an advanced degree of culture in certain limited directions, and not only the material. Their physical existence is sustained on what their flocks and herds produce. To secure adequate grazing for their animals, they wander, sometimes to and fro between recognised summer and winter pastures, and sometimes over still greater distances. In this way, they intercept the fresh vegetable growths brought to birth season by season from the living earth. However successful, it is nothing more than a theft, a harvesting process.

It is presumed, rather than known, that at some period man extended his idea of harvesting to the gathering of the heads of certain plants, thus adding a vegetable element to the milk, meat, and fish he had been deriving from his animals and the chase. Wild barley, rice, and wheat are all supposed to have been gathered in this way in different parts of the earth. But real agriculture only began when, observing the phenomenon of the germination of seeds, instead of consuming all that they had gathered, humans began to save some part of what they had, for sowing in the ground. This encouraged them into settlement, for they had to wait until the plants grew from the seed, and matured.

If at first the small store of gathered seed was sown in any bare and handy patch, the convenience of clearing away forest growths so as to extend the space for sowing soon became apparent. The next stage was to prepare the ground thus won, and so the art of tillage has progressed over the centuries. The use of a pointed stick drawn through the ground is still quite common. The first ploughs were drawn by human labour — a practice which survived even in such countries as Hungary and Romania into the nineteenth century. But the use of animals, tamed for their muscular strength to replace the human team, became the normal and world-wide practice, until it was replaced in certain continents, first by the steam engine, and now by the internal combustion engine.

What was the purpose of this tillage, which is still the prime agricultural process?

1. **The first effect is physical.** The loosened soil makes room for the seed, which thus can grow in abundance, while covering the sowing with scattered earth or pressing it into the ground protects it from the ravages of birds or insects.
2. **Secondly, tillage gives access to the air** — and the process of soil respiration starts up, followed by the nitrification of organic matter and the production of soluble nitrates. The rain, too, can penetrate better.

In this way physical, biological, and chemical effects are set in motion, and a series of lively physiological changes and transformations result from the partnership between soil and plant. The soil produces food materials: the plants begin to grow: the harvest is assured: the sowing has become a crop.

Yet this is not the way in which Nature is accustomed to work. She does not, as a rule, collect her plants, the same plants, in one spot and practice monoculture, but instead she scatters them: and her mechanisms for scattering seed are marvellous and most effective. Man's habit, so convenient, of collecting a specified seed and sowing it in a specified area implies, it must be acknowledged, *a definite interference with Nature's habits*. Moreover, by consuming the harvest and thus removing it from the place where it had grown, man interrupts the flow of natural processes.

In fact, man has laid his hand on the great Wheel and for a moment he has stopped or deflected its turning. To put it in another way, he has, for his own use, withdrawn from the soil the products of its fertility. That man is entitled to put his hand on the Wheel has never been doubted, except by such sects as the Doukhobors, who argued themselves into a state of declaring it a sin to wound the earth with spades or tools.

But if humanity is to continue to exist, we must send the Wheel forward again on its revolutions. This is a necessary part of all primitive cultivation practices, and perhaps a tenet of all true early religions as soon as they lift themselves from the stages of animism or fetish worship; at any rate, all the great agricultural systems which have survived have made it their business never to deplete the earth of its fertility without at the same time beginning the process of restoration. This becomes a veritable, and necessary, preoccupation.

Shifting cultivation

The simplest way of doing this is after a time to leave the cultivated patch, and thus stop the process of interference. Nature will refill it with scrub or forest: soon the green carpet is re-established: in due course humus will accumulate. It will be as it was — the earth's fruitfulness will be restored.

To pass on, therefore, from one patch to another, and again to another and another, is a common primitive practice found in Africa, India, Ceylon, and many other parts of the world, and is known as shifting cultivation.

In this shifting cultivation, the fresh patch is usually cleared by burning the jungle: this leaves the ash *in situ*, and thus retains some of the mineral contents of the burnt vegetation for the benefit of the coming crop.

But it is a wasteful method, for a large aggregate area is required to feed a small group, while a long period has to be allowed to replace the lost fertility. Indeed, this replacement is seldom consummated. The larger trees suffer, the best part of the forest is virtually destroyed. It will also be observed that after using up the riches of the soil, man actually does nothing to restore it — he merely leaves it.

This lazy practice constitutes the least satisfactory of many agricultural systems and, because it requires constant movements of working area on the part of those practising it, *is no foundation for a settled civilisation*. It does, however, show that primitive tribes not only realised the fact that fertility can be exhausted, but also understood how it could be restored.

The harnessing of the Nile

A much more satisfactory method of restoring soil fertility was evolved in the great river valley of the Nile which, according to some theorists, was the original home of agriculture. It is the peculiarity of this great river that it overflows once a year with great regularity, bearing suspended in its flood an accumulation of fertile silt washed down from its catchment basin. This accumulation, rich in both mineral and organic matter, is gently deposited and is capable of yielding an abundant harvest.

The process continued for centuries. Early engineering skill led the silt-laden water to embanked fields by means of irrigation canals. The deposit was trapped just where it was needed, and the land was at the same time saturated with water. When the embanked fields were dry enough, they were ploughed and sown: no rain fell and no more water was needed for a full crop. The annual additions of rich silt made this method of farming permanent. In this way, there developed settled habitations, a great civilisation, and an historic people.

This basin system of irrigation in Egypt, which is perhaps the best and most permanent that can be devised, has of recent years been replaced by another — perennial irrigation — by which the same field can be watered periodically to allow cotton to be grown. For this purpose, the Nile has been impounded, and a vast reservoir has been created for feeding the canals.

But unless the very greatest care is taken to restore and then to maintain the compound soil particles by means of constant dressings of freshly prepared humus, these modern methods are doomed. The too frequent flooding of the close silts of this river valley will lead to the formation of alkali salts, and then to the death of the soil. This will be the fate of Egypt if the powers-that-be persist in the present methods of cultivation of cotton and do not realise before it is too late that their ancient system of irrigation is, after all, the best. Will a few years of cotton growing make up for the loss of the soil on which the life of Egypt is based? On the answer to this question, the future of the Nile valley will depend.

Staircase cultivation

Few areas on the earth's surface are so fortunate as the Nile Valley. What the great river bestowed on the lucky Egyptians has had to be created in other parts of the world, sometimes in the most unpromising conditions.

The so-called 'staircase cultivation' of the ancient Peruvians is one of the oldest forms of agriculture known to us. It dates from the Stone Age. Without metal tools, this people could not remove the dense forest growths of the humid South American valleys. They were driven to the upland areas covered with grass, scrub, or stone.

Here they constructed terraced fields up the slopes of the mountains, tier upon tier, sometimes as many as 50 tiers rising one above the other. The outer retaining walls of these terraces were made of large stones fitted into each other with such accuracy that even today a knife blade cannot be inserted between them. Inside these walls were laid coarse stones and over these clay, then layers of soil several feet thick, all of which had to be imported from beyond the mountains.

Just sufficient slope was given to each tiny field for watering, water also being brought in stone aqueducts from immense distances — one aqueduct of between 400 and 500 miles has been found traversing the mountain slope many hundreds of feet above the valley. Thus a series of gigantic flower pots were formed, and in these were grown the crops to nourish a nation and to establish a civilisation.

The results of such incredible labour are still to be seen, but the Inca nation itself has vanished. However, in the Hunzas living in a high mountain valley of the Gilgit Agency on the Indian frontier, we have an existing demonstration of what a primitive system of agriculture can do if the basic laws of Nature are faithfully followed.

The Hunzas are described as far surpassing in health and strength the inhabitants of most other countries; a Hunza can walk across the mountains to Gilgit 60 miles away, transact his business, and return, all without feeling unduly fatigued. In a later chapter we shall point to this as illustrative of the vital connection between a sound agriculture and good health.

The Hunzas have no great area from which to feed themselves, but for thousands of years they have evolved a system of farming which is perfect. Like the ancient Peruvians they have built stone terraces, whose construction allows admirable soil drainage and therefore excellent soil aeration — for where water drains away properly, air is abundantly drawn in.

As in the ancient Peruvian system, irrigation is employed to obtain the water, and it is interesting that this water is glacial water, bringing down continual additions of fine silt ground from the rocks by the movement of the ice. It is probable — though it has not yet been investigated — that the mineral requirements of the fields are thus replenished to a remarkable degree.

To provide the essential humus, every kind of waste — vegetable, animal, and human — is mixed and decayed together by the cultivators and incorporated into the soil; the law of return is thus obeyed, and the unseen part of the revolution of the great Wheel is faithfully accomplished.

It is this return of all wastes to the soil, including the mud of ponds, canals, and ditches, which is the secret of the successful agriculture of the Chinese.

The startling thing to realise about this peasant nation of many million souls is the immense period of time over which they have continued to cultivate their fields and keep them fertile — at least 4,000 years.

This is indeed a contrast to the shifting cultivation typical of Africa, and it may be observed here that the greatest misfortune of the African continent has been that it never came into contact with the agricultural peoples of the Far East, and so has never revised its systems of cultivation in the light of the knowledge it might have gained. The great lesson of the Nile basin was not truly apprehended and has had no influence outside Egypt — whereas over large parts of eastern Asia, the central problem of agriculture was solved very early, empirically, and not through a process of scientific investigation — and yet with outstanding success.

The Chinese peasant has hit on a way of supplying his fields with humus by the device of making compost. Compost is the name given to the result of any system of mixing and decaying natural wastes in a heap or pit, so as to obtain a product resembling what the forest makes on its floor: this product is then put on the fields and is rich in humus.

The Chinese pay great attention to the making of their compost. Every twig, every dead leaf, every unused stalk is gathered up, and every bit of animal excreta and urine, together with all the wastes of the human population, are used.

The device of the Chinese compost heap is clever. By treating this part of the revolution of the Wheel as a special process, separated from the details of cultivation, time is gained, for the wastes mixed in a heap and kept to the right degree of moisture decay very quickly, and successive dressings can be put on the soil, which thus is kept fed with just what it needs. There is no pause while the soil itself manufactures from the raw wastes the finished humus. On the contrary, everything being ready and the humus being regularly renewed at frequent intervals, the soil is able to feed an uninterrupted succession of plants, and it is a feature of Chinese cultivation that one crop follows another without a pause, indeed crops usually overlap, the ripe crop being skilfully removed by hand from among the young growing plants of the succeeding planting or sowing.

In short, what the Chinese farmer is really doing is ingeniously extending his area by rolling up the floor of the forest and arranging it in a heap. The great processes of decay go on throughout that heap, spreading themselves over the whole of its internal surface, that is, over the whole of the surfaces implied in the juxtaposition of every piece of waste against every other.

He also overcomes the smallness of the superficial area of his holding by increasing the internal surface of the pore spaces of his soil. This is what matters from the point of view of the crop — the maximum possible area from which the root hairs can collect water and food materials for the green leaf. To establish and to maintain this maximum pore space, there must be abundant humus, as well as a large and active soil population.

Thus is created the most intensive agriculture which the world has so far seen. Each Chinese family lives on the produce of a tiny piece of ground, an area which would mean downright starvation in most other countries. In spite of great calamities which repeat themselves — principally floods, the causes of which will be mentioned hereafter — the Chinese peasant may be said to be, on the whole, well nourished. His resisting power to the many frightful diseases, sufficient to kill off most other populations, has been noted, while the standard of culture which he has reached and has maintained over the long period of his existence rivals the contributions of Western civilisation.

The Chinese are indeed an outstanding example of a nation which has conserved the fertility of its soil. Other nations have done the same, but none over so long a period or on so vast an area.

Is it legitimate to interpret the history of nations by the way in which they have made use of their land? We have considered some instances where attempts have been made to conserve fertility with greater or lesser success. Let us now turn to some different examples.

The agriculture of Greece and Rome

Much of the agricultural history of the ancient Greeks is not clear. But one thing is certain: in common with most other Mediterranean peoples, they permitted an extraordinary amount of destruction of forest growths over some of the areas bordering on this great inland sea. Greece is now a land bare of trees, and the continued depredations of the goat have done untold harm to any young growths that have attempted to survive.

Whether this process began on a large scale very early and whether the result was a severe disturbance of the drainage of a not very fruitful country, extending on the one hand the area of marsh and on the other inviting erosion, is not certain. Such conditions would affect first the crops and then those who fed off them — subtle forms of undernourishment, and disease would appear.

The theory has been put forward that the extraordinary and unexplained collapse of the Greek nation in the fourth and third centuries B.C., after a period of the highest vigour and culture, was due to the spread of malaria. It is a theory which is reasonable and would explain much.

The case of the Romans, another Mediterranean people, is not quite the same. For many centuries they maintained a flourishing agriculture, to which they paid great attention.

The backbone of the nation throughout its greatest period was the staunch mass of smallholders, each engaged on cultivating his own farm and only breaking off at intervals to pursue political matters — with great vigour — or to fight the short military campaigns which built the Roman Republic.

In spite of the attractions of the metropolis and of the educational influence with which city life shaped law, thought, and conduct, the rural background was always conserved and valued; religion remained rather rural throughout, and never got far beyond the peasant outlook.

It was the necessity of fighting prolonged foreign campaigns which eventually destroyed all this. Then came the fatal attractions of slave labour. The smallholder was tempted, or indeed was obliged, to desert his holding for years. Such holdings began to be bought up, for wealth accumulated from the spoils of the East. Slaves were drafted in to work these agglomerations of great estates: the evil *latifundium*, which means the plantation in its worst form, spread everywhere. The final phase was reached when tillage was given up for the cheaper pastoral industry; where there had been countless flourishing homesteads, there now ranged great herds of cattle, tended by a few nomadic shepherd slaves.

This disastrous change, which was deeply deplored by such writers as Cicero, lasted — and, except in northern Italy, was not rectified. A few years ago it was possible to see on a mere day's excursion away from Rome a wild shepherd tending his sheep over a ruined countryside which might have been carved out of the most ancient of wildernesses, so entirely was it denuded of all traces of tillage or of the care of man.

There must have been some profound upsetting of the balanced processes of Nature to reduce so fertile a country as Italy to such a state. Nature, in revenge, has preferred to continue her revolution of the Wheel on the lowest gear, spreading her marsh, her scrub, and her desert where once there were fields and meadows.

Having largely destroyed the food-bearing capacity of the Italian peninsula, the Romans were forced to feed their swollen cities from elsewhere. The dispossessed rural population drifted to the towns, which became further congested with a great influx of foreigners and foreign slaves: all had to be fed, and Alexandria and Antioch became problems as intractable in this regard as Rome.

First Sicily and then North Africa, at that time great wheat-growing areas, were exhausted. We cannot trace the process, and do not know how much to attribute to a false economy, or how much to the ravages of centuries of war, as wave after wave of conquerors disputed possession — but when these countries reappear after such cataclysms, Sicily is a wild pastoral country, and North Africa, except for a few coastal tracts and, of course, always Egypt, had become a desert.

Farming in the Middle Ages

The rest of the continent of Europe was more fortunate. Out of the wreckage of the Roman Empire, there finally emerged into medieval times a system of agriculture which held its own well into the nineteenth century. Such a long history is an honourable one, and we may agree that this system, that of *mixed husbandry*, was in many essentials excellent.

Except in situations where a frozen legal system ground down the cultivator — 'trembling peasants gathering piteous harvests' — both the large farm and the smallholding, the landlord and the tenant, survived in good health and in considerable comfort.

Food was abundant and nourishing, and above all the soil remained in good health.

The system depended on three fundamental principles.

1. **Animal husbandry** was practiced alongside the production of vegetable crops: there was thus a ready supply of manure. The manure was not made using the most perfect system — the European manure heap, normally regarded as the inevitable method of collecting and storing animal wastes, is nevertheless most inefficient, as will be pointed out in a later chapter (*Chapter 12, The Reform of the Manure Heap*). However it has played a prime role in maintaining the fertility of our continent, although it is wasteful and extravagant, unhealthy, and unnatural: with the imperfect help of the manure heap, the return of much of the wastes of farming to the land was assured.
2. **Use of wastes.** The use of the cesspit was even less successful, and it is not surprising that water-borne sewage, once it was invented, rapidly replaced it: unfortunately this permitted the final escape of valuable wastes to the sea. To this came to be added, also in the course of the nineteenth century, the further loss of all dustbin refuse which, again on the dictates of the new sanitary science, was destroyed by burning or was buried in landfill. Nevertheless, until these modern sewage disposal methods were developed, it is significant that all material wastes went back to the soil, in however imperfect a way.
3. **The fallow**. Arable land was rested, by allowing it to remain idle for a year or more, through the establishment of a temporary carpet of grass and weeds. A part at least of the advantage of the bare fallow was the benefit conferred by the weeds. When laid down to grass for sheep, the green carpet rapidly deposited a mass of vegetable wastes under the turf which, with the turf and

> the animal wastes deposited on it, provided all the raw materials for sheet-composting when the land came under the plough. Both these methods have been employed in European farming for many centuries and did much to conserve the fertility of the soil.

As long as all these principles governed European farming, it could roughly hold its own, although a slow running down of soil fertility always remained a possibility, as will be seen in the next chapter.

Soil quality began to break down seriously with the advent of the Industrial Revolution. But before dealing with the changes thus brought about in European agriculture, it will be illuminating to examine in greater detail the story of one people — the British — in terms of the use made by the community of soil fertility. We shall see that, in spite of the great and advantageous practices to which we have alluded, soil fertility was subtly, gradually, and inexorably used up.

This has determined much in our national affairs.

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1.3 SOIL FERTILITY IN GREAT BRITAIN

Many accounts of how the present system of farming in Great Britain developed have been published. The main facts in its evolution from Saxon times to the present day are well known.

Nevertheless, in one important respect, these surveys are incomplete. Nowhere has any attempt been made to bring out the soil fertility aspect of this history, and to show what has happened throughout the centuries to a single factor in crop production and animal husbandry — *the humus content of the soil* — on which so much depends.

This chapter is an attempt to make good this omission.

The Roman occupation

At the time of the Roman invasion, most of Britain was under forest or marsh. Only a portion of the uplands was under grass or crops, and the population was very small.

After the conquest of the country, the Romans began to develop it through the creation of an agricultural unit — new to Great Britain — known as the *villa,* on the areas that were already cleared. These villas were large farms under single ownership, run by functionaries who were each responsible for a particular type of animal or crop, and worked by slave labour.

These units followed to some extent the methods of the *latifundia* of Italy, and were designed to produce food for the legions garrisoning the island, and those stationed in Gaul.

Wheat — an exhausting crop — was an important item in Roman agriculture, for the reason that this cereal provided the chief food (*frumentum*) of the soldiers. The extent of the export of grain to Gaul will be evident from the fact that in the reign of the Emperor Julian, no less than 800 wheat ships were sent from Britain to the Continent.

The exhaustion of the soils of the island began even before the Roman occupation. The heavy soil-inverting mould board plough, which invariably wears out the land, was already in use when the Romans arrived, and was probably brought by the Belgic tribes who conquered and settled in the south-eastern part of the country. They lived in farmsteads and cultivated large open fields. They were highly skilled agriculturists, and exported to Gaul a considerable quantity of their main product — wheat. This practice was developed by the Roman villas which followed, and in this way the slow exhaustion of the lighter soils of the downlands of the south-east became inevitable.

After an occupation which lasted some 400 years and which contributed little or nothing of permanent value to the agriculture of the island beyond some well-designed roads, the legions evacuated the island and left the Romanised population to look after itself. This they failed to do: the country was soon conquered by Saxon invaders, in the course of which much destruction of life and property took place. One result was the creation of a new type of farming.

The Saxon conquest

The settlement of Nordic people in our island is the governing event both of British history and of British agriculture. The new settlers had inhabited the belts of land around the Weser and the Elbe, and their first contact with Britain was as raiders; their operations were in the nature of reconnaissance to ascertain the chances of settlement. The Anglo-Saxon migration to Britain was a colonisation preceded by conquest, in which the farming system of the Romanised population was, in the midland area at any rate, destroyed. In the east, south-east, and western portions of the island, some relics of Roman and Celtic methods survived.

Our forefathers brought with them from the opposite shores of the North Sea their wives, children, livestock, and a complete way of village life. The immigrants, being country folk, wanted to live in rural huts with their cattle around them and their land nearby, as they had in Germany. The numerous villages they formed reproduced, in all essentials, those they had left behind on the mainland. Our true English villages are, therefore, not Celtic, and not Roman — but largely and typically German.

The Roman villas were replaced by a new system of farming — the Saxon manor — in which the tenants held land in return for service. The lord and his retainers shared the land, each bound to perform certain duties determined by custom.

These manors took centuries to evolve. By 800 A.D., they had developed into a permanent system which provided the material for the Domesday Book of the Normans, by which taxation was assessed and a rigid feudal system became firmly established.

The open-field system

The first general feature that strikes us in early Anglo-Saxon England is the strip cultivation of the arable land on the open-field system.

This system was a communal agricultural institution, started by people who had to get a living out of the soil. They had progressed so far as to use the plough, and had a common fund of experience, so that everyone used the same system of farming.

The arrangement of the open fields was, however, by no means uniform. No fewer than three distinct types arose, corresponding to as many different influences exerted by people who had occupied the country in earlier times.

The large central midland area, stretching from Durham to the Channel and from Cambridgeshire to Wales, is the region where Germanic usage prevailed.

The south-east was characterised by the persistence of Roman influence, a circumstance which implies that the conquest was less destructive there than in the north and west.

The counties of the south-west, north-west, and the north retained Celtic agrarian usages in one form or another, which is easily understood in view of the difficulty with which, as we know, these districts were slowly overpowered by the invaders.

The midland area was thus the region where the Anglo-Saxons were most firmly established, and where the subjugation of the fifth century was most thorough. The Romano-Celtic people who remained were not numerous enough to preserve any traces of Roman or Celtic methods of tilling the soil.

Throughout this extensive region, a two-field and a three-field system, or sometimes a mixture of the two, prevailed. This field arrangement was a custom prevalent in Germany, especially east and south of the Weser. The chief characteristic of the two and three-field type of tillage was the distribution of the parcels of arable land (which made up the holdings of the customary tenants) equally amongst the two or three fields. The cropping was so arranged that one field in the two-field system and two fields in the three-field system were cropped every year, and thus one-half or one-third of the township's arable land lay fallow and was used for common grazing — a point which is always emphasised in the midland system.

Besides the cultivated open fields, for which the best land was always used, the village lands consisted of grassland for mowing on the wetter parts, and commons or woodlands on the poorer parts.

Ploughing was the all-important operation of medieval tillage, and was carried out on a co-operative basis, and demanded a team of eight draught animals yoked to a heavy plough. This, of course, was beyond the reach of any but the largest and most prosperous tenants. Communal ploughing in Saxon times was, therefore, inevitable. It was the difficulty of replacing this communal ploughing that delayed agricultural progress in many parts of the country.

The open-field system repeated itself for centuries, not only in England but in a great part of Europe — nations living under very different conditions, in very different climates, and on very different soils adopted the open-field system again and again without having borrowed it from each other. This must have resulted from some pressing necessity.

The open-field system is communal in its very essence. Every trait which makes it strange and inconvenient from the point of view of individualistic interests renders it highly appropriate to a state of things ruled by communal conceptions; for example the right of common usage, communal arrangements of ways, and time of cultivation. These are the main features of open-field husbandry, and all point to one origin — the formation in early Anglo-Saxon society of a village community of shareholders of free and independent growth.

So it should be borne in mind that the open-field prevailed during the period of national formation of the English people, and its influence on the life of the village community must have been great. The sense of personal responsibility, which the system of communal work created, made it a vital factor in the social education of the people.

The depreciation of soil fertility

Open-field farming is, as a rule, balanced: the fertility used up in growth is made good before the next crop is sown. Compared with our modern standards, however, the yield is remarkably low, and the removal of fertility by such small crops is made up for by the recuperative processes operating in the soil (non-symbiotic fixation of nitrogen and so forth).

The surplus of available humus originally left by the forest is depleted at an early stage, and an equilibrium is established, the yield adjusting itself to the amount of fertility added each year by natural processes, and this in its turn is influenced by climate and methods of cultivation.

For example, in the peasant cultivation of north-west India in the present day, a perfect balance has been established between losses and gains of fertility. The village land on which corn crops are grown has been cultivated for upwards of 2,000 years without manure beyond the droppings of the livestock during the fallow period between harvest and the rains. But the Indian cultivators use primitive scratch ploughs and are most careful not to draw on the reserves of organic material in the soil, as its texture depends on this. They produce crops entirely on the current account provided by the annual increments of fertility. The yield has settled down to 8 maunds (658 lb.) per acre of wheat on unirrigated land, and 12 maunds (987 lb.) of wheat on irrigated land, and this yield has been constant for many centuries.

The same processes were operating in the English open fields. The reserve of humus in the soils originally under forest, which the Saxons brought into cultivation, was soon used up and the yield was determined by the annual additions of fertility to the soil by natural means. But in our cold and sunless climate and on our ill-drained, poorly aerated soils, this is far less than in the semi-tropical conditions of northern India. Moreover, and this point must be stressed, the Saxons from the earliest times used a soil-inverting plough, which has a marked tendency to exhaust the humus in the soil if provision is not made for the regular supply of sufficient farmyard manure. In fact, recent experience in many parts of the world is proving that the continued use of heavy soil-inverting, tractor-driven implements, without sufficient farmyard manure to manure the land, promptly leads to catastrophic consequences.

The first recorded references to the mould board plough speak of it in Gaul, but some authorities quoted by Vinogradoff (*The Growth of the Manor*) suggest that it was borrowed by the Germanic people from the Slavs, and in view of the soil types found in Slav territory, this may easily be so. The evolution of the big plough was due to soil requirements as settled agricultural life developed in the heavy, moist soils of north Europe after the forests had been cleared.

The mould board plough determined the layout of the open fields. It divided the arable areas into a succession of lands. It needed a headland to turn on, and there was a limit to the length of furrow a team of oxen could plough before needing the relief had by stopping and turning. This 'furrow-long' or *furlong* became one of our units of length.

It was usual to keep the land in high ridges running along the slopes to facilitate surface drainage, an important point in England. The ridges varied in width according to the nature of the soil. In very heavy clays, they were sometimes no more than three yards wide. In lighter soils, they might be 22 yards wide. These ridges may be seen in many places today on grassland which was under the plough in earlier centuries. From this description, it will be seen that the open fields cultivated with the heavy medieval plough were laid out in strips.

The main feature of the heavy mould board plough was its high penetrating power, and it could be used on the heavier types of soil where the light scratch plough of the Celts and Italians would have been useless. It thus enabled the cropped

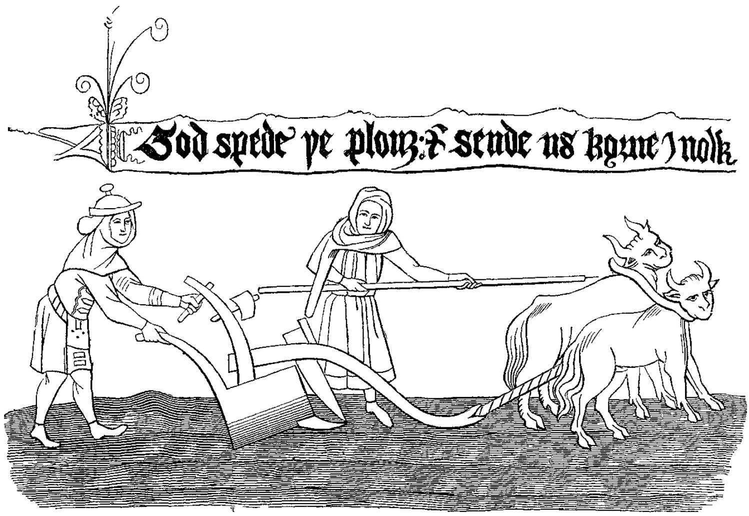

Figure 3. An Anglo-Saxon plough. The text says
"God speed ye plough, and send us corn now."

area in England to be greatly extended by the cultivation of the heavy soil of the valleys and plains which first had to be slowly carved out of the forest. It owed its superiority to an iron share, a courter, and a wooden mould board so suitable on wet land. This primitive implement gave us the plough as we know it today. The principle of our modern plough is identical and, except for the fact that it is now made entirely of iron, it is almost the same in detail.

The open-field system of the Middle Ages was bound to fail eventually because it involved burning the candle at both ends and also in the middle. First the natural recuperative processes in the soil were hampered by low temperatures and poor soil aeration; second, such supplies of farmyard manure as were available were by custom mostly bestowed on the lord's demesne lands, and besides were inadequate because only a portion of the livestock could be wintered; finally the soil-inverting plough led to the oxidation of the stores of soil humus faster than it could be recreated, and was bound to wear out the land.

The low yield of wheat

The failure of the open-field system is proved by the low yield of wheat. All authorities agree that the yield of wheat in England during the Middle Ages was at a very low level, though it does not appear to have varied greatly.

It should be noted that there was never any question of complete exhaustion of the wheat-growing land, such as occurred in Mesopotamia and in the Roman wheat-growing regions of North Africa, where the soil, owing to over-cropping and in some instances to over-irrigation aggravated by special climatic conditions, became sterile and was transformed into desert.

This could not so easily happen in the moist, temperate climate of Great Britain. What happened in the Middle Ages in England was that the yield of corn was not high enough for the requirements of the growing social and economic life of the country.

The data for a quantitative estimate of wheat yields in this period is necessarily scanty, but in the case of some large estates, records are available for a considerable period of years of the seed sown in one year and the grain threshed in the following year, and these form the basis of the best estimates of medieval yields.

Sir William Beveridge (*Economic Journal Supplement*, May 1927), using this method, investigated the yield of wheat for the years 1200 to 1450 on eight manors, including that of Wargrave, situated in seven different counties belonging to the Bishop of Winchester. The average yield per acre was 1.17 quarters, or 9.36 measured bushels, equivalent to 7.48 bushels of 60 lb. It is to be noted that these estimates were all from demesne lands which were probably better cultivated and better manured than the land of the customary tenants. Other authorities confirm these figures.

The figures of yield given above help to account for the changes which marked the end of the Middle Ages. The amount of food was becoming insufficient for the growing population.

But another factor was steadily developing, which finally assumed the dimensions of an avalanche — and led to the reform of manorial farming. This was disease, a matter which must now be discussed.

The Black Death

That the agriculture of the Middle Ages was unable to keep the population in health was first indicated by the frequent indications of rural unrest. But these were soon followed by more serious writing on the wall, in the shape of the Black Death of 1348-9. This outbreak had been preceded by several years of dearth and pestilence, and it was succeeded by four visitations of similar disease before the end of the century.

During its ravages, the Black Death destroyed from one-third to one-half of the population. This seriously affected the labour supply, which was no longer sufficient to carry on the traditional methods of manorial farming, already beginning to be undermined by the growing tendency to replace service with payments of money.

Land which could no longer be ploughed had to be laid down to grass and used for feeding sheep to produce more of the wool so urgently needed in Flanders and Lombardy. For the new farming, the countryside had to be enclosed: first the lord's demesne, and then the area under open fields began to be converted to grass.

The earth's green carpet not only fed the sheep, but gave the land a long rest: large reserves of humus were gradually built up under the turf: the fertility of the soil, which had been imperceptibly worn out by the mould board plough and the constant cropping of the manorial system, was gradually restored.

After a long period of rest — a century or more — the land no longer returned only seven and a half bushels to the acre.

The figures given above for the years 1200 to 1450 may be contrasted with the figures from a farm at Wargrave from 1612-20: in these years the average was 25.6 bushels of 60 lb. per acre (Beveridge, *loc. cit.*). In the latter part of the sixteenth century, the general average was eighteen bushels to the acre and even more. That this significant change was due to the restoration of soil fertility by humus formation under the turf, there can be no doubt.

It is more than probable that the slow regeneration of the soils of this country, which began after the Black Death, produced other results besides the improvement of crops and livestock. What of the effect of the produce of land in good health on the most important 'crop' of all — men and women? Were the outstanding achievements of the Tudor period a natural consequence of a restored agriculture? It may well be so.

Enclosure

When increasing population led once more to the breaking up of the grassland and the farmer returned to tillage, the land, after its long rest of a century or more, was again capable of responding to the demands made upon it.

One result of this experience was an increased interest in enclosure. Instinct was leading to a search for an economic arrangement which would prevent soil exhaustion from being repeated in succeeding ages. Enclosed farms offered a solution, as they gave the farmer the chance of keeping his land in good condition by individual management, rather than the easy-going farming of the open fields of old English village agriculture. They also offered to the enclosed farmer the opportunity of composting his straw in his cattle yards and producing as much farmyard manure as possible. This, in most cases, he did, and the plan succeeded.

Nevertheless, the ancient open-field tillage husbandry had had in its favour the authority of long tradition — a potent force with a suspicious and conservative peasantry. The peasant asked himself: in the case of a readjustment of holdings, would not the strong profit and the weak suffer? There grew up a popular prejudice against enclosure and the improvement of the common fields, but in the end, after some centuries of contest, enclosure won.

The form which the enclosure movement took before it was completed was due to the peculiar form of government which came in with the English Revolution of 1688. By that event, the landed gentry became supreme. The national and local administration was entirely in their hands, and land, being the foundation of social and political influence, was eagerly sought by them. They not unnaturally wished to direct the enclosure movement into channels which were in the interests of their estates. But in doing so, they made some of the most outstanding contributions to farming ever made in our history.

The restoration of soil fertility which resulted from enclosure had a profound influence on both livestock and crops. The provision of more and better forage and fodder which followed the cultivation of clover and artificial grasses, coupled with the popularisation of the turnip crop by Townshend in 1730, opened the door for the continuous improvement of livestock by pioneers such as Bakewell.

The result was that our livestock improved in size and in the quality of the meat. Between 1710 and 1795 the weights of cattle sold at Smithfield more than doubled. By 1795 cattle weighed 800 lb. as compared with 370 lb.; sheep went up from 28 lb. to 80 lb.

The improvement in the yield of cereals was no less significant. That of rye or wheat rose from 6-8 bushels to the acre in the Middle Ages to 15-20 bushels; barley yielded up to 36 bushels, oats 32-40 bushels. All this was due to more and better food for the livestock, and more manure for the land. More manure raised larger crops: larger crops supported much bigger flocks and herds.

Another change in the countryside accompanied the enclosures. The forests, which since Saxon times had been gradually cleared and converted into manorial lands, were exhausted. After the Civil War it was realised that the country was running short of the hardwoods needed for maintaining the fleet and for buildings, and so forth. An era of tree planting, which continued for two hundred years, was inaugurated by the publication of John Evelyn's *Sylva* in 1678. It was during this period that the English landscape as we know it today was created by the judicious laying out of parks, artificial lakes, groups of trees, and entire woods.

All this planting provided an important factor in the maintenance of soil fertility. The roots of the trees and the hedges combed the subsoil for minerals, embodied these in the fallen leaves and other wastes of the trees and shrubs, and so helped to maintain the humus in the soil, as well as the circulation of minerals. The roots also acted as subsoil ploughs and aerating agencies. The cumulative effect of the trees and hedges which accompanied enclosure in maintaining soil fertility has passed almost unnoticed. Nevertheless, its importance in humus production and in the availability of minerals must be considerable.

While the policy of enclosure, combined with tree-planting and the creation of the existing English landscape, arrested the fall in soil fertility which was inherent in the open-field system, the freedom of action which followed enclosure gave full scope to the improver.

The restoration of British agriculture owes much to the pioneers among the landlords themselves, particularly to Coke of Holkham (1776-1816), who did much to introduce the Norfolk 'four-course' system — turnips, barley, seeds (clover and rye grass), and wheat — into general practice and so to achieve at long last a system approximating Nature's law of return. Besides his championship of the Norfolk four-course system, his achievements include the conversion of 2,000,000 acres of waste into well-farmed and productive land, the prevention of famine in England during the Napoleonic Wars, the solution of the rural labour problem in his locality by means of a fertile soil, and the demonstration of the principle that money well spent on land improvement is an excellent investment. He invested half a million sterling in his own property, and thereby raised the rent roll of his estate from £2,200 a year to £20,000. He transformed agriculture in this country by the simple process of first writing his message on the land and then, by means of his famous sheep-shearing meetings, bringing it to the notice of the farming community.

But the replacement of the manorial system by individual farming in fenced fields brought with it some grave disadvantages. The large profits obtained from the sale of wool, for example, while they enriched the few, led to a new conception of agriculture. The profit motive began to rule the farmer; farming ceased to be a way of life, and soon became a means of enrichment. Enterprising individuals found considerable scope for using their farms to make money. At the same time, large numbers of less fortunate individuals deprived of their land had either to work for wages, or seek a living in the towns.

The various *Enclosure Acts*, which covered a period of more than 600 years, from 1235 to 1845, therefore led to a new agriculture, the enthronement of the profit motive in the national life, and to the exploitation of coal, iron, and minerals, which is customarily referred to as the Industrial Revolution. This arose from the activities of the tradesmen of the manor, whose calling was destroyed by the Acts.

The last of the *Enclosure Act*s, which finally put an end to the strip system of the open fields, was passed in 1845. About the same time, the celebrated Broadbalk wheat plots of the

Rothamsted experimental station were laid out. This field is divided into permanent parallel strips and cultivated on even more rigid lines than anything to be found in the annals of manorial farming. These plots never enjoy the droppings of livestock: until recently they never had the benefit of the annual rest provided by a fallow. Practically every agricultural experiment station all over the world has copied Rothamsted and adopted the strip system of cultivation.

How can such experiments, based on an obsolete method of farming, ever hope to give a safe lead to practice? How can higher mathematics and the ablest statistician overcome such a fundamental blunder in the original planning of these trials?

The strip system has also been adopted for the allotments around our towns and cities without any attempt whatsoever on the part of the authorities to maintain the land in good health by such obvious and simple expedients as subsoiling, followed by a rest under grass grazed by sheep or cattle, ploughing up, and sheet-composting the vegetable residues. Land under allotments should not be under vegetables for more than five years at a time; this should be followed by a similar period under grass and livestock.

The Industrial Revolution and soil fertility

The released initiative which accompanied the collapse of the manorial system was by no means confined to the restoration of soil fertility and the development of the countryside.

The dispossessed craftsmen started all kinds of industries, in which they used as labour-saving devices first water power, then the steam engine, the internal combustion engine, and finally electrical energy. By these agencies the Industrial Revolution, which continues to this day, was set in motion.

It has influenced farming in many directions. In the first place, industries have encroached on and seriously reduced the area under cultivation. But by far the most important demand of the Industrial Revolution was the creation of two new hungers — the hunger of a rapidly increasing urban population and the hunger of its machines. Both needed the things raised on the land: both have seriously depleted the reserves of fertility in our soils.

Neither of these hungers has been accompanied by the return of the respective wastes to the land. Instead, vast sums of money were spent in completely side-tracking these wastes and preventing their return to the land which so sadly needed them. Much ingenuity was devoted to developing an effective method of removing the human wastes to the rivers and seas. These finally took the shape of our present-day water-borne sewage system. And the contents of the dustbins of house and factory first found their way into huge dumps and then into incinerators or into refuse tips sealed by a thin covering of cinders or soil.

At first the additional demands for food and raw materials were met by the restored agriculture and the periodical ploughing up of grass. One of these demands was the vast quantities of corn needed to feed the urban population. The price of wheat was regulated for more than 150 years by a series of 'Corn Laws', which attempted to hold the balance between the claims of the farmers who produced the grain and those of the consumers and the industrialists who advocated cheap food for their workers, so that they could export their produce at a profit. But as the urban population expanded, the pressure on the fertility of the soil increased until, in 1845, a disastrous harvest and the potato famine compelled the Government in 1846 to yield. The 'rain rained away' the Corn Laws.

Deprived of protection, farmers were forced to adopt new methods and to farm intensively. Many developments in farming occurred. Particular attention was paid to drainage: the first drain pipe was made in 1843; two years later the pipes were turned out by a machine. Liebig's famous essay in

1843 drew attention to the importance of manures. While better farm buildings and the preparation of better farmyard manure were adopted, two fatal mistakes were made:

1. artificial fertilisers such as nitrate of soda and superphosphate came into use; and
2. imported feed for livestock began to replace home-grown food.

British farming, in adopting these two expedients — because they appeared for the moment to be profitable — laid the foundations of much future trouble. But in the use of better implements for the land and the provision of improved transport facilities, the countryside was on firmer ground.

The result of all these and other developments was a period of great prosperity for farming, which lasted until late in the seventies of the last century.

The Great Depression of 1879

Then the blow fell. The year 1879, which I remember vividly, was one of the wettest and coldest on record. The average yield of wheat fell to about fifteen bushels to the acre: large numbers of sheep and cattle were destroyed by disease: the price of wheat fell to an undreamt-of level as the result of large importations from the virgin lands of the New World.

The great depression of 1879 not only ruined many farmers, but it dealt the industry a mortal blow. Farmers were compelled to meet a new set of conditions — impossible from the point of view of the maintenance of soil fertility — which have been more or less the rule until the Great War of 1914-18 and World War 2 provided a temporary alleviation as far as the sale of produce and satisfactory prices were concerned.

Since 1879, the standard of real farming in this country has steadily fallen. The labour force, particularly the supply of men with experience of and sympathy with livestock, markedly diminished and deteriorated in quality. Rural housing left much to be desired. Drainage was sadly neglected. The small hill farms, which are essential for producing cattle possessing real bone and stamina, fell on evil days. Our flocks of folded sheep, so essential for the upkeep of downland, dwindled. Diseases such as foot-and-mouth, tuberculosis, mastitis, and contagious abortion became rampant.

Less and less attention was paid to the care of the manure heap and to the maintenance of the humus content of the soil. The NPK mentality (*Chapter 6, The Shortcomings of Present-day Agricultural Research*) replaced the 'muck mentality' of our fathers and grandfathers. 'Improved' bread, deprived of the essential germ, replaced the real bread of the last century and seriously lowered the efficiency of our rural population. The general well-being of our flocks and herds fell far below that of some of our overseas competitors, such as Argentina.

But in this dark picture, some rays of light could be detected. The pioneers were busy demonstrating important advances. Among these, two are outstanding:

1. the Clifton Park system of farming based on deep-rooted plants in the grass carpet; and
2. the use of the subsoiler for breaking up pans under arable and grass, and so preparing the ground for another great advance — the mechanised organic farming of tomorrow.

The Second World War

Such, generally speaking, was the condition of British agriculture in September 1939, when the Second World War began and the menace of enemy submarines for the second time made national starvation a possibility. An opportunity was provided for Thomas Coke of Norfolk to make use of a portion of the resources of a great nation to set British farming on its feet for all time by the simple expedient of restoring and maintaining soil fertility! What an opening was given to the pioneers of human nutrition and the apostles of preventive medicine for feeding the men and women defending the country on the fresh produce of fertile soil — and so initiating the greatest food reform in our history.

But the potential other 'Cokes of Norfolk' had been liquidated or discouraged by many years of death duties, which had destroyed most of our agricultural capital and deprived the countryside of its natural leaders who, in years gone by, had done so much for farming. The apostles of real nutrition and of preventive medicine, such as the panel doctors of Cheshire, were ignored. (See *Medical Testament*)

A much easier road was taken. The vast stores of fertility, which had accumulated after the long rest under grass, were cashed in and converted into corn crops.

The seed obtained saved the population from starvation, but most of the resulting straw could not be used because of the shortage of labour to handle it, and of insufficient cattle to convert it into humus.

The grow-more-food policy was, therefore, based overwhelmingly on the exhaustion of the soil's capital. It is a perfect example of unbalanced farming. It is therefore certain to sow the seeds of future trouble, which will be duly registered by Mother Earth in the form of malnutrition, and diseases of crops, livestock, and mankind.

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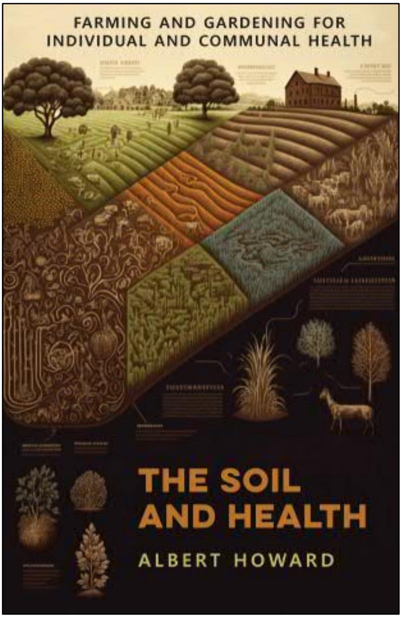

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This valuable book is a detailed analysis of the vital role of humus and compost in soil health – and the importance of soil health to the health of crops and the humans who eat them. The author is keenly aware of the dead end which awaits humanity if we insist on growing our food using artificial fertilisers and poisons.

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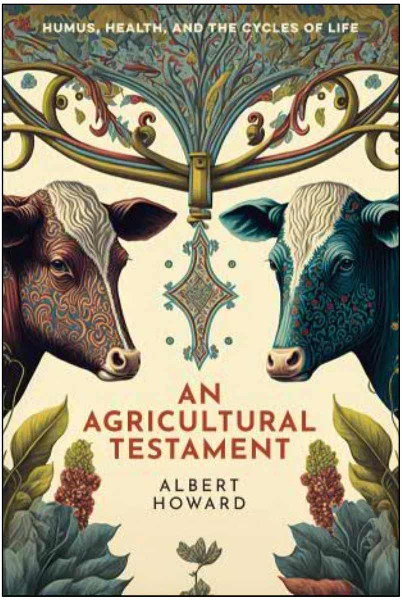

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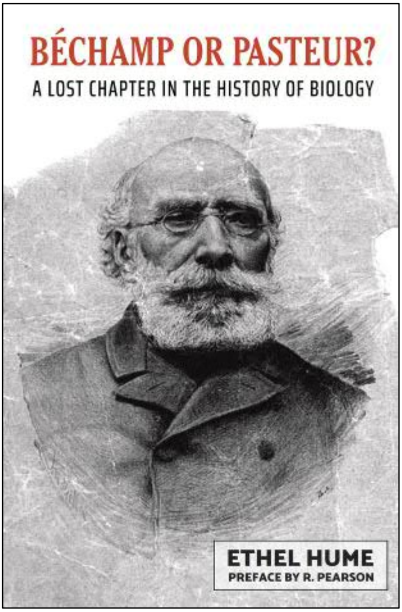

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Ethel Hume / Robert Pearson

Pearson's *Pasteur: Plagiarist, Imposter* was originally published in 1942 and is a succinct introduction to both Louis Pasteur and Antoine Bechamp, and the background to the troubled relationship that they shared for their entire working lives. Ethel Hume documents the evidence in detail, so that there is no escaping the obvious conclusion – Pasteur was a fraud.

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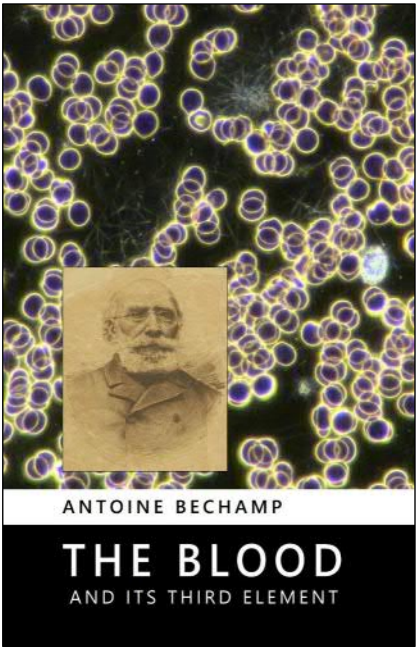

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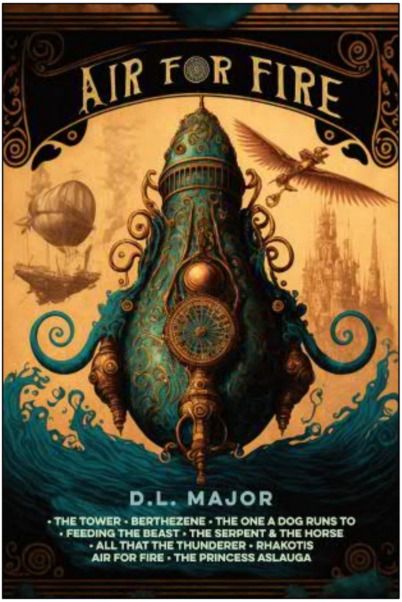

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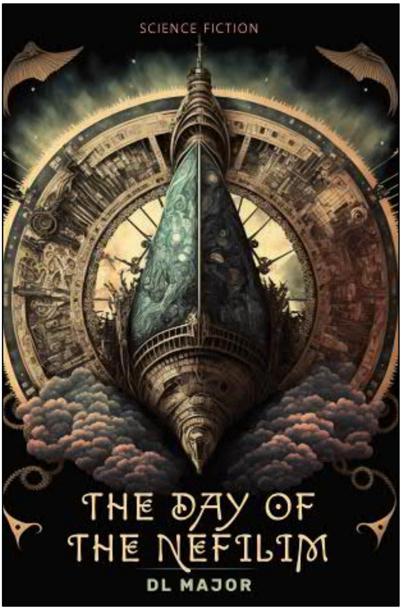

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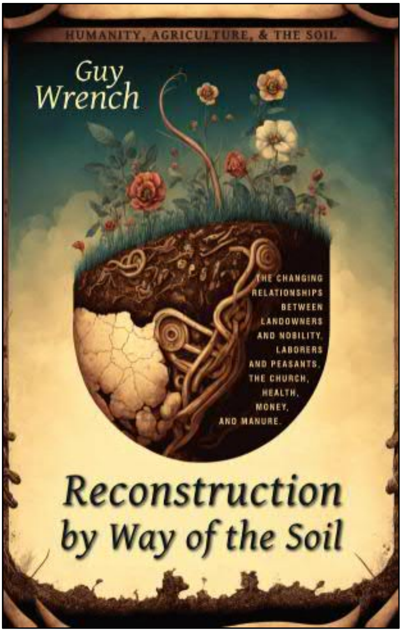

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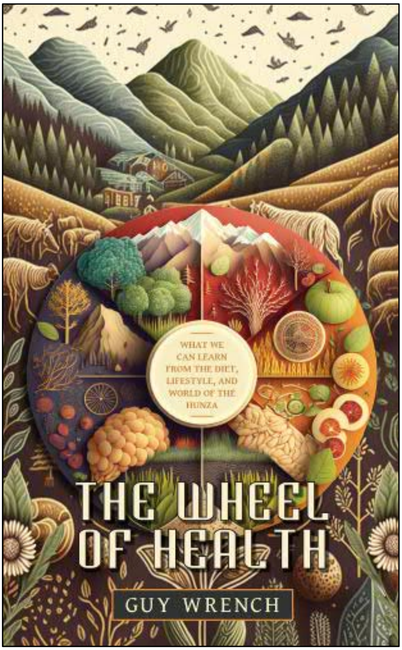

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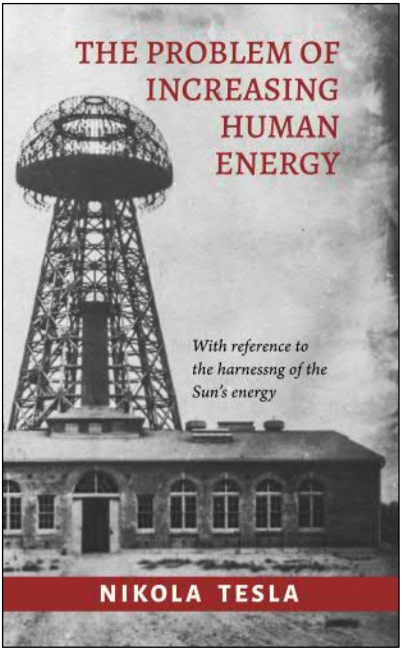

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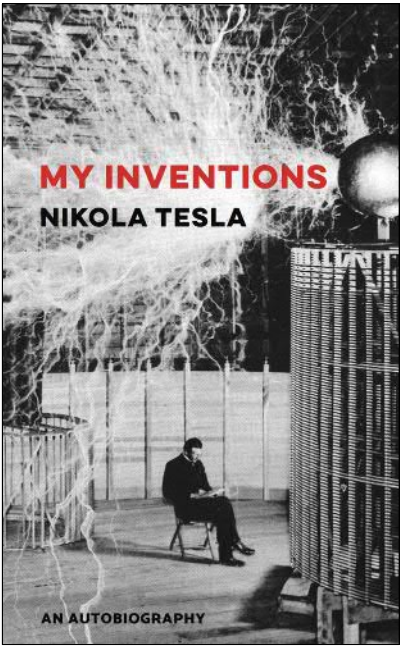

My Inventions

Nikola Tesla

Not only is this book an invitation to meet one of the greatest minds of the last century, and to hear him talk about his inventions;
it is also a chance to get to know Tesla as a person, as the book is filled with anecdotes of his early life.

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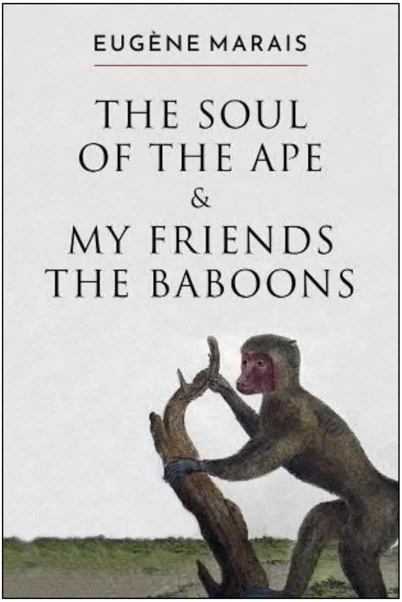

The Soul of the Ape

Eugène Marais

Includes two works by Marais written after his period spent living among a troop of baboons in the South African veldt. *My Friends* was written for a newspaper readership. *The Soul of the Ape* was the more serious scientific document. The excellent introduction by Robert Ardrey was part of the 1969 edition, and adds greatly to an appreciation of the importance of this text.

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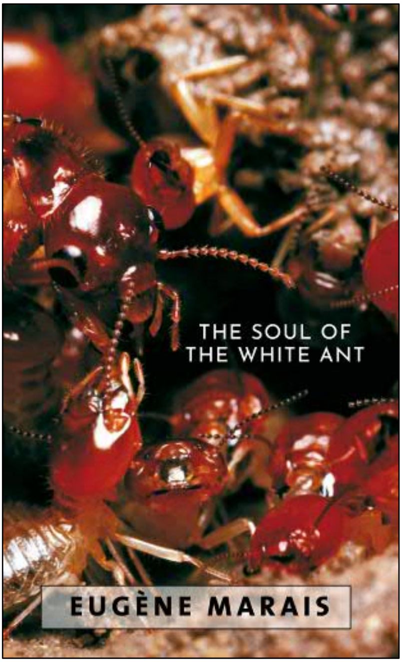

The Soul of the White Ant

Eugène Marais

The amazing results of a long, close study of the lives of termites. Eugène Marais compares the infrastructure of a termitary to that of the human body. Writing from the heart, this scientific author who is also a poet instills a wonder in the reader, of the incredible intricacies of nature, in a light-hearted, easily readable manner.

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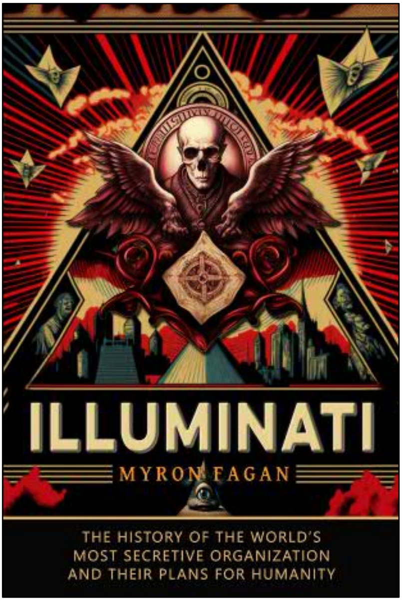

Illuminati

Myron Fagan

This book describes how the Illuminati became the instrument of the Rothschilds to achieve a One World Government, and how every war during the past two centuries has been instigated by this group. This is an historical text with names, dates, organizations and mode of operations, all exposing the octopus gripping the world today.

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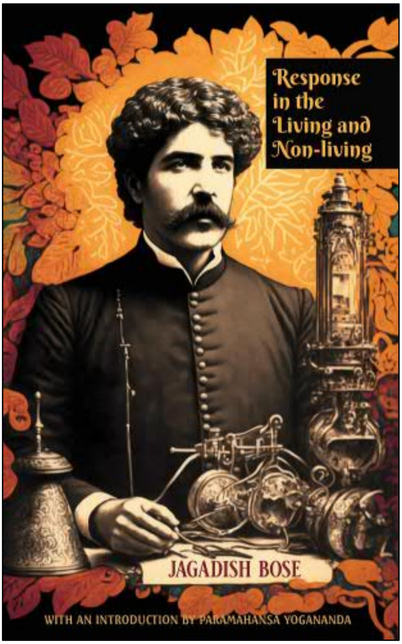

Response in the Living and Non-living

Jagadish Bose

This is one of the great Indian scientist's earlier works. His experiments showed that in the entire range of responses – regardless of whether the subject is metallic, plant or animal – the responses are identical. The living response, in all its diverse modifications, is a repetition of the responses seen in the inorganic. *Everything is alive.*

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Ten Acres is Enough

Edmund Morris

Recently we have seen a great back-to-the-land movement, with many young professional people returning to small scale farming; thus it is useful to read about someone who did exactly the same thing in 1864. In that year, Edmund Morris and his family gave up their business and city life for a farm of ten acres, where they made a go of mixed farming, and then wrote a book about it.

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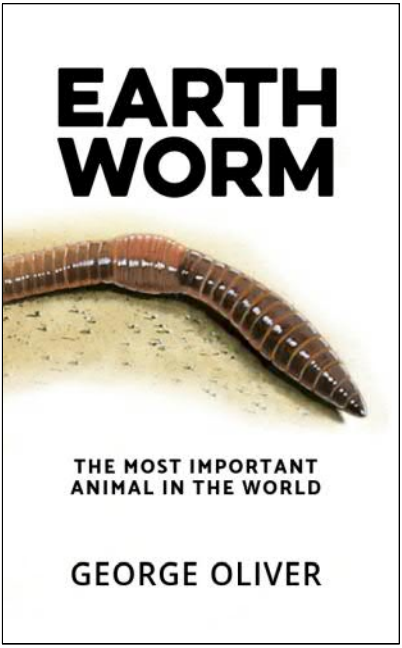

Earthworm

George Oliver

The author returns the reader to a time and methodology where people took responsibility for what they did and what they produced. In this world of spiraling food prices, huge landfills, diminishing food supplies, loss of topsoil, and water pollution, the reader is reminded that the world's most important animal could well be the humble earthworm.

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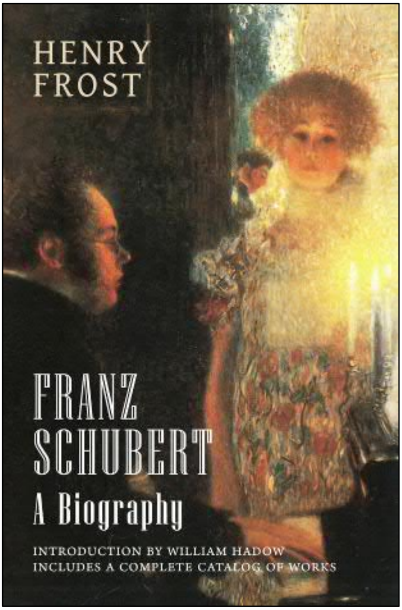

Franz Schubert – a Biography

Henry Frost

"With faith man steps forth into the world. Faith is far ahead of understanding and knowledge; for to understand anything, I must first of all believe something. Faith is the higher basis on which weak understanding rears its first columns of proof; reason is nothing but faith analysed."
– *Franz Schubert*

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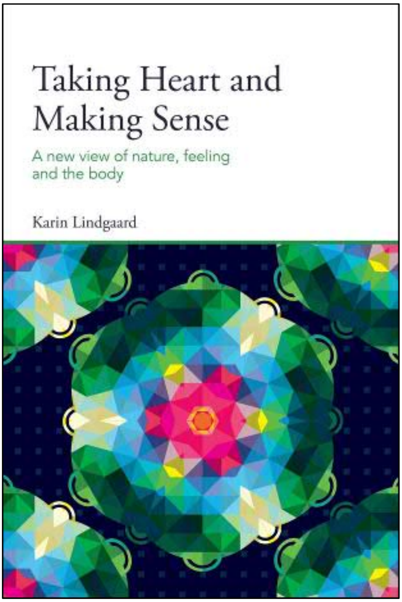

Taking Heart and Making Sense

Karin Lindgaard

What do animals feel? How do living systems become conscious?

The author takes on these and many more questions about the natural world and human experience, helping us to understand our feelings and emotions, and our sense of meaning in life. Lingaard takes readers on a conceptual adventure across psychology, philosophy and cognitive science.

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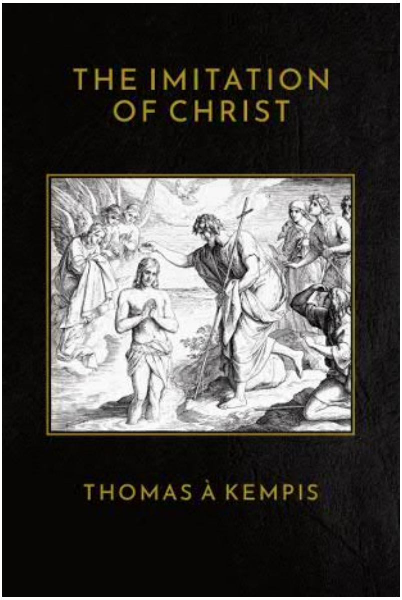

The Imitation of Christ

Thomas à Kempis

A new edition, extensively illustrated with prints by Julius Schnorr von Carolsfeld and featuring many bible passages from the RSVCE Bible. This text has long been a treasure trove for Catholics around the world. With its beautiful illustrations and carefully selected Bible passages, this new edition brings timeless wisdom to life like never before.

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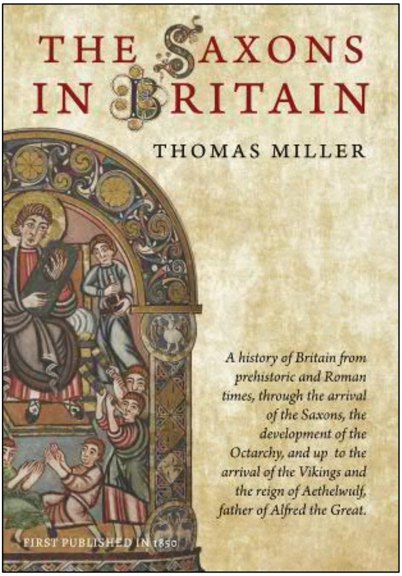

The Saxons in Britain

Thomas Miller

An illustrated history of Britain from prehistoric and Roman times, through the arrival of the Saxons, the development of the Octarchy, and up to the arrival of the Vikings and the reign of Aethelwulf, father of Alfred the Great.

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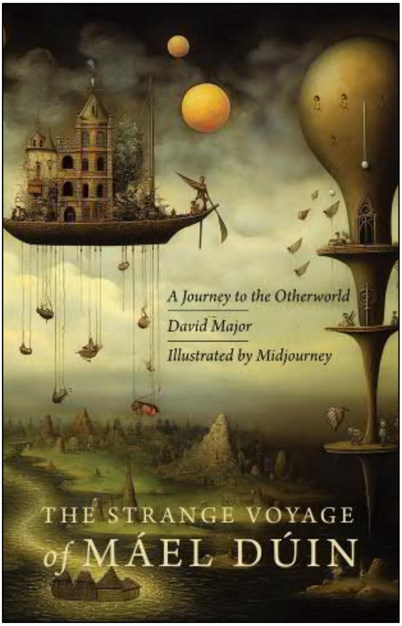

The Strange Voyage of Máel Dúin

David Major & Midjourney

A new edition of one of the great stories of Irish mythology. It is extensively illustrated in full color by Midjourney, at the time of publication the leading AI illustration tool.

A collaboration between human and artificial intelligence, the Strange Voyage of Máel Dúin is a legendary tale from Gaelic literature that holds a significant place in the traditions of myth and history. It recounts the extraordinary maritime journey of the heroic Máel Dúin and his companions as they embark on a perilous quest.

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